MINUTES OF PROCEEDINGS

OF THE

ROYAL ARTILLERY INSTITUTION.

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TRANSLATION

OF A ROYAL DECREE PASSED RECENTLY IN THE

ITALIAN PARLIAMENT.

BY CAPTAIN MAYNARD WOLFE, R.A.

THE accompanying translation of a Royal decree, passed recently in the Italian Parliament, may be of some interest at a time when the re-organization of their armies is the subject of much consideration throughout nearly all the nations of Europe.

This alteration appears to have been made principally with a view to economy, as may be seen by reference to the annexed table, under the head "Transition State." It should be remembered, however, that Italy contains a large number of young men, who from want of occupation or idleness, are ever ready to join in any expedition; and as the "Camicil Rosse"* of last year, did actually nothing towards the result of the campaign, it is believed that many who would have joined any irregular force of that description will now be induced to join the army, hence that reduction in figures of the war strength, exists purely on paper, more especially as the war footing was never actually maintained at its strength. This re-organization has given rise to a large number of articles, pamphlets, and reviews; and the general feeling expressed both in them, and in conversation, appears to be rather averse to the change as proposed to take effect on the 1st January, 1868.

Victor Emanuel II. by the grace of God, and by the will of the Kingdom of Italy.

I. *Recruiting.*

ART. 1.—The decree made public by the law of the 25th March, 1854, and which took effect from the 1st July, 1854, relative to the ranks of the first class of the army, who were called upon to serve for eight years in the active army and three years in garrison corps, (ART. 2) but whose term of service might expire on the completion of the 5th year, is repealed, (ART. 3) and the following exception is made to the terms of this decree :—

(*a*) In the cavalry such soldiers of the 1st class as have enlisted for ten years in the active army, their period ceases with a service of five years.

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* Red shirts, or Garibaldians.

(*b*) The soldiers of the 1st class in the train and the administrative portion of the army who may have entered for thirteen years, their service ceases at the end of three years.

(*c*) All persons mentioned in the decree of the 25th March, 1854, are also amenable to this herewith published.

Art. 4. In time of peace the annual contingent of the 1st class will be called out during the months of March and April.

Art. 5. The decree made public by the law of the 20th March, 1854, for the ranks of the 2nd class dates from the 1st October subsequent to their enrolment* and is completed by the first three years service in the ranks of the active army.

Art. 6. The instructions for soldiers in the 2nd class during the first year of their service will extend to three months, or more, according to the amount of money disposable for military expenditure in the treasury.

Art. 7. The ordinary enlistment† authorized by the law of the 20th March, 1854, is abolished.

Art. 8. Any individuals of the 2nd class who, forming part of the active army, contract a marriage without the authority of the Minister of War, are amenable to the Art. 182, of the Law of Recruiting of 20th March, 1854.

II. *On Organization.*

Art. 9. The army is divided into two parts, the active and the garrison corps. The first constitutes the permanent force of the nation; the second can only be called out either entirely, or in part, by a royal decree of mobilization either for the service of war or for providing for the public order.

Art. 10. In time of peace the troops composed in Schedules A and B herewith annexed are constituted as in the said schedules.

Art. 11. The strength of the troops composed in the Schedules A and B herewith annexed are published by royal consent, and can only be changed by the Act of the Parliament passed yearly.

Art. 12. The staff, non-combatant corps, military institutions, and the various other services either for discipline or administration be they either active or garrison, who not being mentioned in Schedules A and B herewith annexed, are however included in the vote for military expenditure, and continue to remain constituted as they now are.

They can only receive any changes, as would cause an increase of expenditure, by the passing of an Act of Parliament yearly.

III. *On the Reserve.*

Art. 13. In order to constitute a reserve for the garrison corps, an addition is herewith made, relative to the position of the officers, to that of the 25th May, 1852.

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* "Assenzo." † "Surrogazione."

Officers must pass into the reserve at the age mentioned opposite each rank of the army,—

Lieut.-Generals	62 years.
Major-Generals	60 „
Colonels	58 „
Lieut.-Colonels	52 „
Majors	52 „
Captains	48 „
Lieutenants.................	45 „
Sub-Lieutenants	45 „

Officers in the reserve who are not included in the garrison corps may be employed, in the event of mobilization, in the district commands; and also in such other services in the interior of the country as may be suitable to their rank.

Art. 14. Officers may be transferred into the reserve at the expiration of twenty-five years service if they be lieutenants or sub-lieutenants, or at the expiration of thirty years if of any other rank, provided they have not exceeded the limit of age laid down in the preceding article.

Art. 15. Officers of the reserve have a right to the following addition of pay, to their pension, on entering into the reserve:—

	Francs.
Lieut.-General	400 yearly.
Major-General	400 „
Colonel	300 „
Lieut.-Colonel.................	250 „
Major	200 „
Captain	150 „
Lieutenant	100 „
Sub-Lieutenant	100 „

Art. 16. Officers of the reserve called upon to serve in accordance with Art. 9 of the present decree, have a right to the pay assigned to officers of corresponding rank in the active army.

Art. 17. When by the fact of passing into the reserve on account of age, an officer should not have completed twenty years service, giving him a right to pension, he will receive however the pension according to his rank, without the additional allowance mentioned in Art. 15.

Art. 18. Officers of the reserve will retire from the service at the ages mentioned opposite their respective ranks,—

Lieut.-General	70 years.
Major-General	68 „
Colonel	66 „
Lieut.-Colonel and Major ...	60 „
Captain	55 „
Lieutenant	52 „
Sub-Lieutenant	52 „

The fact of passing into the reserve does not nullify the powers and the rights of the law in pensions, for the government and other military officers now in force.

Art. 19. Officers who have completed twelve years service in any rank at the time of entering into the reserve, or on the completion of twelve years service in that rank shall be promoted to a higher grade, and such officer so promoted will receive the pay and any addition to the pay belonging to his new rank in accordance with the dispositions of Article preceding, viz. 15.

Art. 20. The length of service passed in the reserve will only count as one-third, either for the promotion referred to in the preceding article or for the computation of the emolument belonging to the newly acquired rank in the reserve, or for the arrangement of the pension at the time of retiring from the service. The service of the officers of the reserve will however count entirely for such time as it may be mobilized in accordance with Art. 8 of the present decree.

Art. 21. In order to complete, in the subordinate ranks, the skeletons of the garrison corps, and on account of the necessity of filling up the vacancies, permission is given to non-commissioned officers to pass an examination for the position of the higher rank, provided they have voluntarily enrolled themselves and have completed five years service; such non-commissioned officers as may be found qualified will pass into the garrison corps as sub-lieutenants, and be required to serve for a period of ten years.

Art. 22. These officers have no claim to any pay, unless they may be called upon to serve in accordance with Art. 9, in which case they will receive the sum laid down in that article; they have no right to pension unless in the course of their service they may have entered into one of the conditions which in accordance with this decree would give them a claim to pension.

Art. 23. Officers of the reserve and also the officers mentioned in the preceding article, when not on active service, have a similar footing, with respect to privileges and position, as other officers, as laid down by the decree of the 25th May, 1852, and other laws and rules in force.

IV. *Commands.*

Art. 24. To facilitate the transaction of military affairs, the nation is divided into the following description of commands:—

(*a*) Generals commanding.
(*b*) " of division.
(*c*) " of districts.
(*d*) Commanders of a fortress.

Art. 25. The number of commands is laid down in Schedule C, with reference to the foregoing article.

V. *Temporary Arrangements.*

Art. 26. Whenever the numbers of the first class of the army, alluded to in Art. 1 of this decree, fall below 48,000 men, that article is annulled, and the term of service will be; the first nine years in the active army, and the other two in the garrison corps.

Art. 27. The decree laid down in the preceding is applicable to those soldiers of the 1st class, who on the 1st January, 1868, form part of the active army, be they either actually under arms or on unlimited leave.

The transfer therefore of such classes from the active army into the garrison corps, will be regulated from time to time by the Minister of War.

Art. 28. The present decree will come into force on the 1st January, 1868.

Art. 29. Such laws for the army as now exist, and not being contradicted by any of these, will still remain in force.

Schedule A.

Infantry.—Seventy-two regiments, four of which are grenadiers. Each regiment is composed of one head-quarters and three battalions; each battalion is composed of four companies.

Bersaglieri.—Five regiments. Each regiment is composed of one head-quarters and nine battalions; each battalion of one head-quarters and four companies.

Cavalry.—Twenty regiments. Each regiment is composed of one head-quarters and six squadrons.

Artillery.—One regiment of pontoniers composed of one head-quarters and seven companies.

Three regiments of garrison artillery, each composed of one head-quarters and sixteen companies.

Five regiments of field artillery, one composed of one head-quarters, two batteries of horse and fourteen of field artillery; and four composed of sixteen field artillery batteries.

Engineers.—The body of sappers is composed of one head-quarters and twenty-eight companies.

Train.—The train is composed of one head-quarters and four brigades, each brigade being composed of four companies.

Administrative.—The administrative body to be composed of one head-quarters and six companies.

SCHEDULE B.—*Garrison Corps.*

Infantry.—Ninety-six battalions, each composed of one head-quarters and four companies.

Bersaglieri.—Twelve battalions, each composed of one head-quarters and four companies.

Artillery.—Twenty-four companies.

Engineers.—Six companies.

SCHEDULE C.—*Commands.*

4 generals commanding.
21 〃 of division.
38 〃 of districts.

Commanders of fortresses will be employed by royal authority declaring towns to be fortified places, and where there may be no other commander. The following is a parallel, or comparison between the strength of the rank and file of the army of the organization of the 30th December, 1865, and that of the proposed organization, both in its normal state and period of transition.

	Force organized by decree 30th Dec. 1865.		New organization.				The new organization in relation to that of 31st Dec. 1865.							
	Peace establishment.	War establishment.	Normal force.		Transition state.		Normal state.				Transition state.			
							Peace.		War.		Peace.		War.	
			Peace.	War.	Peace.	War.	+	—	+	—	+	—	+	—
Active army......	199,736	363,221	208,348	328,447	174,330	289,882	8,612	〃	〃	34,774	〃	28,406	115,000	73,339
Garrison Corps..	〃	〃	〃	140,000	〃	115,000	〃	〃	140,000	〃	〃	〃	〃	〃
Second Class (to assist the active army)	〃	171,904	〃	102,000 *	〃	132,000 *	〃	〃	〃	69,904	〃	〃	〃	39,904
National Guard.	〃	135,000	〃	〃	〃	〃	〃	〃	〃	135,000	〃	〃	〃	135,000
Total ...	199,736	670,125	208,348	570,447	174,330	536,882	8,612	〃	140,000	239,678	〃	28,406	115,000	248,243
							8,612 increase		decrease 99,673		decrease 28,406		decrease 133,243	

* The true figures are 105,000 and 135,000, but they are diminished by 3000 men, who were included in the war strength of the administrative body of the active army.

N.B. The effectives of the active army either in time of peace, or on a war footing, contain an unvarying total of 25,000 men, who represent the various "employés" in the staff and other small bodies for the purposes of organization; these are included in the strength of the army and have existed up to this time, in the same manner as they now exist, only now in a larger proportion in consequence of the alteration of the elements that are combined in its formation.

ON A CLINOMETER

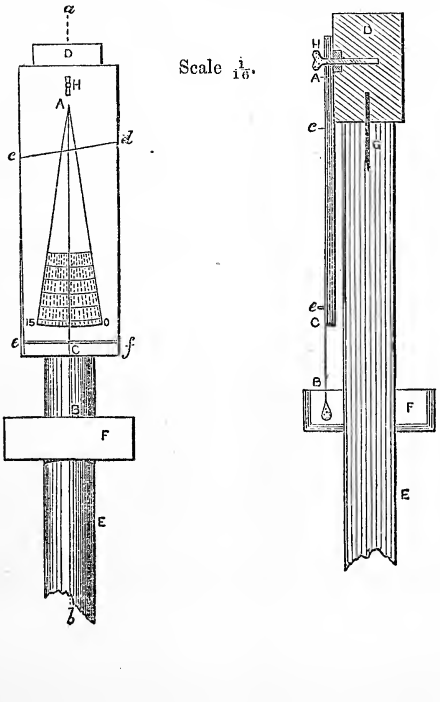
FOR

ELEVATED COAST BATTERIES.

BY CAPTAIN J. R. OLIVER, R.A.

It is most desirable that in every Coast Battery there should be some means at hand of at once ascertaining the exact distance of any particular object, and also of obviating the necessity of a reference to range tables—an invariable source of confusion and delay in actual warfare. With this view the following contrivance has been devised, and clinometers of this pattern are now being constructed for two new 68-pr. batteries at St Helena; one of which is 460 feet, the other 610 feet above the sea.

An upright post (*E*) about four inches diameter, and five feet high is fixed in a convenient part of the battery. At its top and in the direction of its axis is a brass rod (*G*) which serves as a vertical axis for the clinometer to revolve on. Lower down a sort of bucket (*F*) through the bottom of which the post passes, is placed, and serves to protect the plummet of the clinometer from the wind. A rectangular block (*D*) of teak, or other hard wood, with a hole at one end for the brass rod to enter, fits in to the top of the post and carries with it a rectangular board (*AC*) of mahogany, $24'' \times 8'' \times \frac{1}{2}''$, which is clamped to it by means of a screw (*H*) passing through a nut.


Front elevation. Sectional elevation through *ab*.

Scale $\frac{1}{16}$.

AC,	Clinometer.
AB,	Plumb line.
E,	Post.
F,	Box to protect the plummet from the wind.
G,	Fixed metal axis.
D,	Moveable wooden block.
H,	Clamping screw.
cd,	Sights.
ef,	Guard to steady the plumb line.

This board is covered with white paper on which the graduation, &c. is marked. From the point *A* a plummet is suspended by a fine silk line which is prevented from swinging from the face of the board by a guard *ef*. The graduation is from 0 to 15°, and along a line *cd*, perpendicular to that joining the point *A* with the zero mark, a couple of fine sights (or a small telescope with cross wires) are placed.

The sector forming the actual clinometer is marked on the white face of the board. Its radius is 18 inches, and this size allows it to be graduated without difficulty to every 15 minutes. The sector is divided by a number of concentric circular arcs, as shown in the figure. In one of these divisions the ranges in yards corresponding to the degrees of depression are marked. In the next one the tangent scale elevations for round shot and shrapnel are given. In the next the elevation for common shell. In the next the length of fuze for ditto, &c. &c. All of these being legibly printed in the direction of the radii. Before they are finally inked in, their correctness is ascertained by actual practice. The ranges are of course found by dividing the height of the battery above the sea (in yards) by the sines of the angles of depression.

The post, with its bucket and brass pin, is a fixture in the battery, but the block *D* and clinometer lift off it, and are kept with the other gun stores. On the guns being prepared for action the clinometer is brought out and slipped on to the post. As it turns freely round *G* and also round the screw *H*, when unclamped, the sights *cd* can be at once directed on any required object. The screw is then clamped, *and the range, elevation, &c. &c. read off on the radius the plumb line coincides with.* I have found this instrument to answer perfectly. It gives the range of an object to a nicety, and even the dip of the horizon can be exactly ascertained by it. It is very simple in its construction, costs little, and can be made up by any carpenter. The most stupid man can use it, provided he knows how to read, since all he has to do is to turn the sights on the object and clamp the instrument, when the indicator tells him everything he wants to know.

Of course if there be more than one nature of gun in the battery there will be more divisions required on the board, but in this case it would be easy to have a separate clinometer for each calibre.

It is very difficult to hit ships in motion with any degree of certainty, but where this clinometer is used in batteries at any considerable height above the sea, the uncertainty will be reduced to a minimum, since the exact distance of a ship can be read off at any instant, and the proper amount of elevation called out at the same time.

EXTRACTS FROM REPORT

ON

BALLISTIC EXPERIMENTS CARRIED ON DURING THE YEARS 1861-2, UNDER THE DIRECTION OF THE O. S. COMMITTEE.

BY CAPTAIN W. H. NOBLE, M.A., R.A.

ASSOCIATE MEMBER, ORDNANCE SELECT COMMITTEE.

1. The determination of the velocity of projectiles is indispensable to the necessary calculations which belong to the theory of gunnery.

The most primitive method of estimating this velocity was by measuring the ranges of the projectiles on a horizontal plane. This method was employed by Lombard in 1797. It is unnecessary to enumerate the difficulties with which it is surrounded.

The case to which it was most applicable was the determination of the velocity of mortar shells.

The estimation of velocities, by observing the total duration of a projectile's flight in the air, that is to say, the time of its ascent and descent combined, is subject to less causes of error, but the difficulty of noting the time with sufficient minuteness is a great obstacle. Subsequent to the invention of the Ballistic Pendulum of Robins, several methods were adopted for measuring the velocity by the time a projectile occupied in passing from one point to another in the trajectory. One of the first of these is due to Mattei, about 1767.*

INSTRUMENTS FOR MEASURING TIME.

Mattei's Machine of Rotation. Fig. 1.

2. Mattei's machine consisted of a vertical cylinder of paper or thin cardboard fixed to a wooden frame, to which a certain velocity of rotation was given, and musket balls were fired against it in a direction perpendicular to the axis of the cylinder. The difference between the deviation of the holes that the ball had really made and of those it would have produced if the cylinder had been at rest gives the time of flight comparatively to the time of an entire revolution of the cylinder; as, moreover, by means of

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* Lieut. de Butet, of the Italian service, seems to have been before Mattei. Vide par. 6, p. 13.

screens placed in the direction of the ball's flight, we can determine the line of fire, and consequently the length passed over in the cylinder, we can estimate the velocity of the ball in its movement across the apparatus. The precision by this means depended upon the size of the diameter of the cylinder, as well as the rapidity and uniformity of rotation that was given to it. The velocity of rotation was obtained by a weight descending into a well.

Mathei's Machine of Rotation.

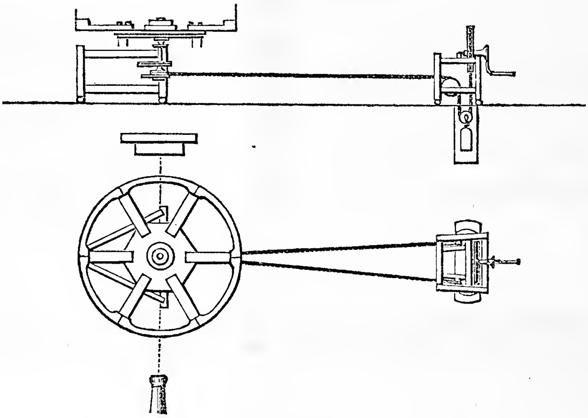

Fig. 1.

The velocity with which the shot passes through the diameter of the cylinder, and consequently its uniform velocity during one second of time, is found as follows:—

Let D be the diameter of the cylinder, C its circumference, t the time that it takes to make one revolution, m the distance that a point of the circumference turns while the shot is traversing the diameter, then

$$m : D :: C : \frac{CD}{m}$$

the last term will express the space passed through by the shot with a uniform velocity during one revolution of the cylinder; then, expressing by V the space that the shot passed through with a uniform velocity in one second, or its initial velocity,

$$t : 1 :: \frac{CD}{m} : \frac{CD}{tm};$$

the last term $= V$ will express the velocity sought.

In general, the cylinder turned with an equable motion of $t = \frac{1}{5}$ of a second, $D = 10$ feet, consequently $C = 31{\cdot}42$ feet; substituting these values in the expression for the velocity,

$$V = \frac{CD}{tm},$$

and supposing m to be found by experiment equal to $\frac{1}{4}$ of a foot, $V = 1571$.

The following tables show velocities computed by the above equation from data furnished by Mattei's machine of rotation.

Table I.

GIVING THE VELOCITY OF SHOT FIRED UNDER VARIOUS ATMOSPHERIC CIRCUMSTANCES.*

Mattei's Machine.

Nature of gun.	Length of bore.	Projectile.		Charge.	Velocities in weather.		
		Nature.	Weight.		Very moist.	Mean.	Very dry.
	ft.		oz.	drs.			
Musket com. war powder.......	3·5	Lead.	1	7	1392	1542	1618
Fine 〃	〃	〃	〃	〃	1569	1736	1829
Fowling 〃	〃	〃	〃	〃	1566	1703	1784
Firework 〃	〃	〃	〃	〃	1566	1706	1779

If the velocities given in this table can be depended on, they prove that the gunpowder used in Mattei's time must have been very inferior.

Table II.

SHOWING THE VELOCITY OF DIFFERENT GUNS, WITH VARIOUS KINDS OF POWDER, COMPUTED FROM MATTEI'S MACHINE.

Nature of gun.	Length of bore.	Projectile.		Charge.	Velocity.	Powder.	Remarks.
		Nature.	Weight.				
	in.		oz.	drs.	ft.		
Musket.........	22	Lead.	1·00	7	1390	F. war.	
〃	〃	〃	〃	〃	1367	Fowling.	
〃	〃	〃	〃	〃	1372	Fire-work.	
Rifled carbine.	41	〃	0·875	7	1956	F. war.	
〃	〃	〃	〃	〃	1920	Fowling.	
〃	〃	〃	〃	〃	1934	Fire-work.	
Wall-piece ...	66	〃	2·50	20	1956	F. war.	
〃	〃	〃	〃	〃	1928	Fowling.	
〃	〃	〃	〃	〃	1923	Fire-work.	
Musket.........	42	〃	1·00	7	1736	F. war.	
Wall-piece ...	66	〃	3·5	23	1770	〃	
〃	〃	〃	3·0	〃	1855	〃	
〃	〃	〃	3·0	〃	2068†	〃	† Of the same diameter as the first shot, a small pebble put in the centre while casting.
Musket.........	42	〃	1·00	5	1399	〃	
〃	〃	〃	〃	7	1736	〃	
〃	〃	〃	〃	10	1984	〃	
Wall-piece ...	66	〃	2·50	11·5	1504	〃	
〃	〃	〃	〃	18	2056	〃	
〃	〃	〃	〃	25	2060	〃	
Musket.........	11	〃	1·00	7	1037	〃	
〃	22	〃	〃	〃	1390	〃	
〃	44	〃	〃	〃	1736	〃	
〃	64	〃	〃	〃	1815	〃	

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* "Treatise on Gunpowder and Fire-arms," by Gen. D'Antoni.

*Grobert's Machine of Rotation.** Fig. 2.

3. Col. Grobert, a French officer, modified this proceeding of Mattei about the year 1804. His apparatus consisted of two very thin discs of card-board, each divided into 360° by equal radii, that is, equally graduated. These discs were attached to the extremities of a shaft, to which a rapid movement of rotation was given. If the machine was at rest, the ball when fired would pierce both screens on the same radii, but when a rotation was given, there was a certain interval between the time of passing the first screen and the second, and the difference between the degrees of radii indicated the angle, and from it was calculated the time of flight of the shot in passing from the first screen to the second, and consequently the velocity. Thus, let x equal the angle denoted by the two radii struck, y the interval between the two discs, and T the duration of one revolution of the discs, the time that the projectile has taken in traversing the distance y will be

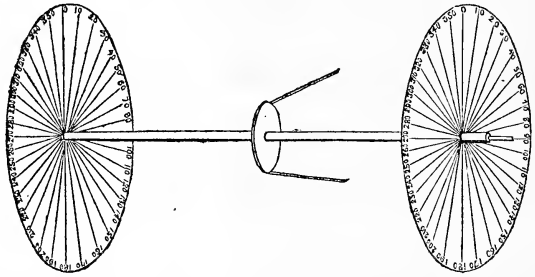
$$t = \frac{x}{360} T,$$

and the velocity of the ball will be

$$V = \frac{y360}{Tx}.$$

Grobert's Machine of Rotation.

Fig. 2.



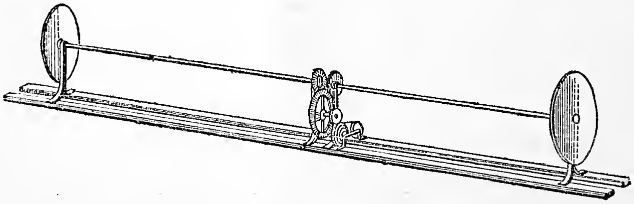
This instrument was unable to measure the time with greater accuracy than the $\frac{1}{20}$ of a second, and consequently gave no practical results.

Gregory's Machine of Rotation. Fig. 3.

4. Next in order of time, about the year 1818, comes Gregory's machine of rotation, which is very similar to that of Grobert. But none of

Gregory's Revolving Discs.

Fig. 3.



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* Traité de Ballistique, par M. Didion.

these machines proved successful. It was found almost impossible to give a uniform motion of rotation, and they were not able to measure with greater accuracy than to about the $\frac{1}{30}$ of a second. Thus we might possibly commit an error of $\frac{1}{30}$ of a second, which, with a ball at a velocity of 1400 feet per second, would amount to almost 50 feet. Gregory professed to measure to the $\frac{1}{150}$ part of a second, but even that admitted of too great an error.

5. About 1760, General D'Antoni, of the Sardinian army, estimated the velocity of projectiles by firing them into a homogeneous butt of known consistency. Its consistence was determined by the use of a standard gun, whose velocity had been ascertained by other means, and whose penetrations into the butt with a given charge ought always to be the same. The gun was placed near the butt, and several shots were fired to obtain a mean, taking care to fire each shot into a fresh part of the butt. Thus, suppose the consistence of the butt to have been determined equal to 96,000, then

$$V = \sqrt{\frac{96000 \times x}{d}},$$

in which

V = velocity required,
x = mean penetrations in feet,
d = diameter of ball in feet.

Experiments made by this method gave the following velocities.

Table III.

SHOWING THE VELOCITY OF SHOT DETERMINED BY FIRING INTO A BUTT OF KNOWN CONSISTENCY.

Nature of gun.	Weight of projectile.	Charge.	Velocity.	Remarks.
	lbs.	lbs.		
32-pr.	32	12	1349	Common cannon powder used.
16-pr.	16	6	1433	Mean atmosphere.
8-pr.	8	4	1530	
4-pr.	4	2	1510	

6. In addition to those already mentioned, it appears that in 1764 Lieut. De Butet, of the Italian service, invented the following machine for determining initial velocity. He applied a little plate of metal, provided with a moveable index, to any wheel that turns with a regular constant motion and sufficient velocity. The index is held at some distance from the circumference of the wheel by a thread that is stretched across the mouth of the gun. When the gun is fired, the shot breaks the thread and sets a spring at liberty, which instantly presses the index against the wheel, upon which it describes an arc, until it is checked by the impact of the shot against a moveable butt, placed at the distance of a few feet. For this

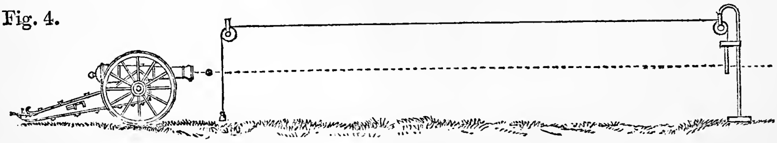
purpose one extremity of a rod is fastened to the butt, and the other to the plate, by which means the index is drawn back by the rod, which follows the movement of the butt, and no longer describes the arc in the circumference of the wheel.

The motion of the wheel, the distance of the muzzle of the gun to the butt, and the arc described by the index being known, the initial velocity of the projectile can be calculated.*

It need not be remarked that this primitive arrangement had many disadvantages and sources of error.

7. Col. Debooz, of the French Artillery, about the year 1838 proposed to measure the velocity of a projectile by an apparatus founded upon the free fall of a body (Fig. 4). At about 50 yards from the gun is placed a fixed screen, before which, and extremely close to it, a moveable screen is suspended by means of a fine thread, the other extremity of which passes over two pulleys, one near the screen, the other over the muzzle of the gun, and is fixed to a weight. The gun is fired, the projectile cuts the thread, and the moveable screen begins to descend; the two screens then are perforated by the bullet almost at the same instant; the perforations show how far the moveable screen has fallen, and consequently the time which has elapsed from the cutting of the string till it was pierced. This time ought to correspond to that employed by the projectile in passing the 50 yards. It was tried at Liége in 1840, and gave velocities too great. The error is attributed to the friction of the thread on the pulleys, the fall of the screen not coinciding with the instant of the cutting of the thread. The gas, also, was likely to burn the thread before the shot had reached it. If h is the height or distance through which the moveable screen falls, then

Fig. 4.



$$t = \sqrt{\frac{2h}{g}},$$

t being the time of flight.†

Ballistic Pendulums.

8. In order to avoid the difficulty experienced in measuring the time of flight of a body in rapid motion, the idea was conceived of lessening the velocity by firing the projectile against another body heavier than itself, to which it would communicate the quantity of motion that it lost; the velocity is thus reduced in the ratio of the weight of the heavier body, plus the projectile, to the weight of the projectile.

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* Vide "Treatise on Gunpowder and Fire-arms," p. 86, by General D'Antoni. Translation by Captain Thomson, R.A.

† Traité de Ballistique, par M. Didion.

9. Mr Robins was the first who took advantage of this idea, and constructed his celebrated ballistic pendulum, in which he imparted the velocity lost by the projectile to a large block of wood suspended by an axis, about which it was free to move in the direction of the shot's motion.

Robins' Ballistic Pendulum. Fig. 5.

10. Robins' ballistic pendulum consisted of a broad plate of iron, on which was bolted a wooden plank about nine inches square. It was suspended by means of a wooden shaft and axis, the extremities of which rested in sockets screwed into the upper ends of two poles, a third pole formed with these a tripod, which supported the whole apparatus. Near the bottom of the two poles a brace was fastened, having a contrivance fixed to it, through which a ribbon ran with very slight friction. One end of this ribbon was made fast to the pendulum, and the other end lay on the ground.

Robins' Ballistic Pendulum, 1743.

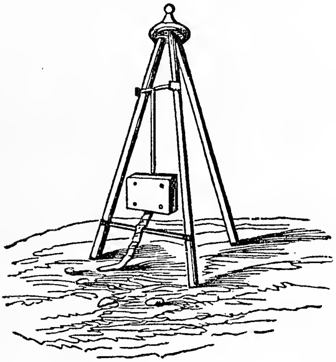


Fig. 5.

When the gun was fired, the ball struck the pendulum, causing it to oscillate and pull out the ribbon. The length pulled out corresponded to the vibration of the pendulum, and consequently to the force of the blow it had received. From this was computed the velocity of the ball.

11. The invention of the ballistic pendulum by Mr Robins is an epoch in the history of the science of gunnery. He was the first who seems to have entered upon this subject with the determination to grasp the many difficulties with which it was surrounded. Previous to Robins' time, the most erroneous theories had been advanced by many philosphers. Thus, Galileo, in the fourth of his Dialogues on Motion, 2nd Edition, p. 384, demonstrated that a projectile in its flight would describe the curve of a parabola, *except so far as the resistance of the air should cause it to deviate;* but Galileo formed a very inadequate estimate of the amount of this resistance. Mr Robert Anderson, in his "Genuine Use and Effects of the Gunne," published in 1674, and also in "To Hit a Mark," published in 1690, adopts this theory of Galileo without any modification.

This theory was, however, disproved by Huyghens, who showed, in a treatise published in 1690, that the path of the projectile would be a logarithmic curve, if the resistance was proportional to the velocity. Sir Isaac Newton appears to have been the first who proposed a theory that the resistance was proportional to the square of the velocity. John and David Bernoulli, Herman, Brook Tayler, &c. have also written, about this time, on the subject of the air's resistance to the motion of projectiles.

It is, however, to Mr Robins that we owe much of the progress that has been made in the science of gunnery.

Mr Robins published an account of his invention in a treatise on the "New Principles of Gunnery," printed in 1743.

The experiments made by Mr Robins were conducted with musket balls, and the largest pendulum employed by him weighed but 97 lbs.; and yet the results of subsequent investigation in different countries, assisted by every improvement which mathematical or mechanical science could devise, have but served to corroborate the *fundamental* laws laid down by him; a singular proof how much more work depends on the workman than on his tools. Robins' work was translated into German by M. Euler, who added elaborate notes and remarks. This translation was re-translated into English by Mr H. Brown in 1777, and received several valuable additions by Mr Landen, a gentleman of high mathematical talents. Mr Robins has not investigated the nature of the curve described by a projectile in a resisting medium, but this has been done by Euler, Robinson, Legendre, and others.

Shortly before the publication of Mr Brown's translation of Euler's Robins, Dr Charles Hutton was appointed Professor of Mathematics at the Royal Military Academy, Woolwich, and in 1775 he commenced a series of experiments in gunnery. These experiments were carried on by means of a ballistic pendulum, constructed according to the method invented by Mr Robins, but much larger than the instrument used by the latter. The smallest pendulum used by Dr Hutton weighed about 600 lbs., and in the prosecution of his experiments new pendulums were made successively larger and larger, till he at length reached a weight of about 2600 lbs. In these investigations, Dr Hutton was led to make many improvements in the construction of the ballistic pendulum, especially in the manner of suspension and method of measuring the angle of recoil. Dr Hutton's experiments were carried on at Woolwich, and were most extensive and valuable; they extended from the year 1775 to 1791.

In 1778 he published a report of his first series of experiments; this report being presented to the Royal Society, was honoured by them with the gift of the annual gold medal, and printed in the Philosophical Transactions for 1778.

The results of Dr Hutton's valuable experiments are fully discussed in his work on the subject.

In addition to the experiments with the ballistic pendulum, a series of observations on the resistance of the air to bodies moving with low velocities were made by Dr Hutton, by means of the whirling machine invented by Mr Robins. As this machine has been described by so many authors, it is not my intention to refer again to it. It is fully explained in Colonel

Boxer's "Treatise on Artillery," and Sir Howard Douglas has also alluded to it in his valuable work on "Naval Gunnery."

The original instrument is preserved in the Royal Artillery Institution.

12. In July, 1814, the Ordnance Select Committee recommended the construction of a large ballistic pendulum capable of sustaining the shock of a 24 lbs. ball fired with a charge of 8 lbs. This pendulum was primarily intended for the purpose of comparing the effects of guns constructed on Sir William Congreve's principle, which consisted in an alteration and re-distribution of the metal on the *exterior* of the gun. Sir William Congreve erroneously supposed this would have the effect of increasing the initial velocity, and consequently the range.

The experiments were carried on in Woolwich Arsenal, under the superintendence of the Ordnance Select Committee, assisted by Dr Gregory, the Professor of Mathematics at the Royal Military Academy.

The pendulum weighed about 7400 lbs., and was supported by means of parallel walls 7 ft. apart. No gun pendulum was used in the experiments. Fig. 6.

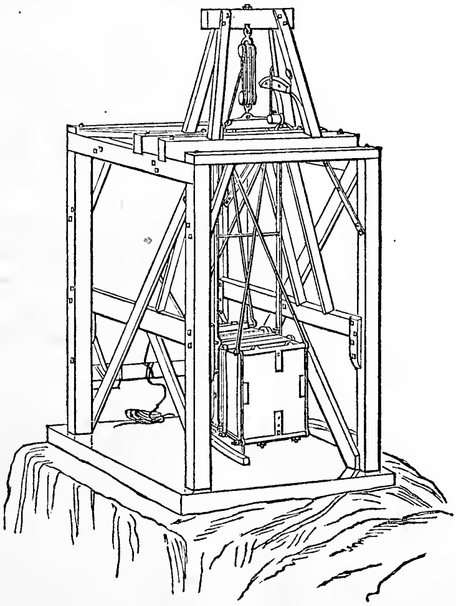


Fig. 6.

Ballistic Pendulum of 1814, from a model made to a scale of $\frac{1}{8}$th. Full weight about 7440 lbs. Centre of gravity below centre of suspension 10·97 feet. Centre of oscillation below centre of suspension 11·88 feet.

The first series was for the purpose of comparing the velocities of three 6-pr. guns of the same calibre, viz.,—

	Length of bore. ft.	Length of bore. in.
Sir Thomas Bloomfield's	4	$4\frac{1}{2}$
Sir William Congreve's	4	5
Long gun	5	$7\frac{5}{8}$

The guns were placed at a distance of 30 ft. from the pendulum, and fired with a shot of 6·109 lbs, and charges of 1·5 lbs. and 2·0 lbs.

The velocities were as follows:—

	1·5 lbs. ft.	2·0 lbs. ft.
Sir Thomas Bloomfield's	1451·7	1676
Sir William Congreve's	1439·8	1616
Long gun	1497·3	1761

These results were decisive, and proved that Sir William Congreve was mistaken in his theory. Two rounds were, however, fired from 24-prs. of the same construction, with a charge of 4 lbs., and shot of 24·875 lbs.; the velocities were,—

	ft.
Sir William Congreve's	1242·5
Long service gun	1292·6

Distance of gun from pendulum, 46 feet.

Probably this is the first experiment which was ever made with large guns and a ballistic pendulum.

Several other experiments were carried on by Dr Gregory by means of this pendulum, and it was finally removed from the Royal Arsenal in the year 1836, and placed in the Royal Military Repository, where it now exists.

I regret that want of space does not permit my giving a detailed account of these experiments; they embraced velocities with 6, 12, 18, and 24 lbs. shot.

An abridged account may be found in "Annales de Chimie et de Physique," tome 5, 1817; tome 9, 1818; and in M. Dupuis' work on the "Military force of Britain."

In 1820, ballistic pendulums of cast-iron were constructed in France, but they were not found to answer in consequence of the tendency of the projectile to split and rebound. A core of lead was then tried, with not much better success. This had been previously tried by Hutton, who found it not to answer; *vide* Tract 34, sect. 46.

In 1836, MM. Morin and Piobert constructed a pendulum for the experiments at Metz, which contained many improvements.

This instrument was used with projectiles of large calibre. It is fully described in General Didion's "Traité de Balistique."

(*To be continued*).

ERRATA.

page 32, line 9 from bottom, *for* "loading," *read* "firing."

„ „ 10 „ *for* "nearly up," *read* "nearly back."

„ „ 11 „ *for* "well up," *read* "well back."

MONCRIEFF'S PROTECTED BARBETTE SYSTEM.

BY CAPTAIN A. MONCRIEFF,

EDINBURGH MILITIA ARTILLERY.

Before defining the mechanical part of this invention, it may be as well to state the results hoped to be obtained by it, and the principal difficulties that had to be encountered.

The conditions desired were simply to obtain a system of firing over a solid parapet, while preserving free lateral range, and neither exposing the gun and detachment, nor involving the labour of raising and lowering the piece; in other words, of gaining the advantages of a barbette battery, without its defects.

The difficulties on the other hand were mechanical ones, but mechanical difficulties of a very serious kind, and which I doubt not have often discouraged those who have been on the same track as myself; for it is impossible to suppose that this idea has not been entertained by many others. The advantages to be obtained, are too important, not to have often invited invention.

It was the consciousness of this that stimulated me to persevere with my experiments at considerable expense, and under great discouragement, and delay.

Before the end of the Crimean campaign I began to design lifts for guns, and in the course of this work, the principle I now adopt, occurred to me; as soon as it did so, I felt I had an agent suited for the purpose.

A mechanism for raising and lowering the gun might with comparative ease be contrived were the strains statical, but they are very different, and those who know most about the difficulties of meeting the recoil of modern heavy ordnance on the platforms and slides now used, and the destructive effects large charges produce on pivots, and racers, will probably be most ready to appreciate the difficulty I refer to, where, as in my case, the strain of the recoil has not to be met near the plane of its own action, as in these platforms and slides, but far below it.

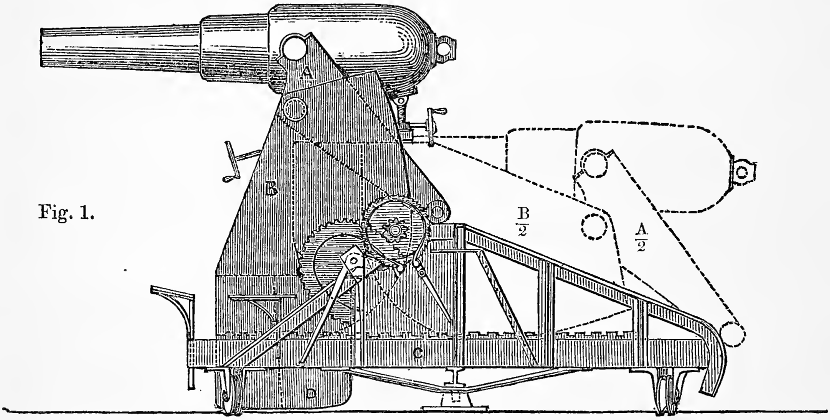
The danger of the sudden strain imposed on the platform is removed by interposing a moving fulcrum between it and the gun, at the same time meeting the energy of the recoil by counterweight or some force of equivalent power. This arrangement reduces the initial velocity of the counterweight to a minimum (without destroying equilibrium). The force of the recoil is conveyed to the gun on the discharge taking place—the energy thus generated, in fact, the destructive power, is measured by the weight of the gun multiplied into the square of its velocity. If therefore the velocity conveyed to the counterweight, is at first almost disposed of, the *vis inertiæ* of that counterweight has no longer a destructive action on the intermediate parts. It is by this means alone that such enormous strains and weights can be dealt with in a structure possessing little more strength than would be required for statical support. Moreover greater durability to material may be anticipated under continued action, than is obtained with carriages on which recoil is stopped by friction alone.

In the proposed arrangement the recoil is stopped without injurious strain by an arrangement of forces analogous to those which stop the rolling of a ship, where the gradual rising of the centre of gravity of the whole structure puts a limit to the movement in one direction. The curve of the elevators can be made to control the meta-centre, and express the same movement, with nearly the same results.

Fig. 1 shews the general arrangement of a Moncrieff carriage for a 7-ton gun. It consists of three principal parts, viz.—

The Carriage Proper, *A*; The Elevators, *B*; and The Platform, *C*.

Fig. 1.



$\frac{A}{2}$ and $\frac{B}{2}$ shew the carriage and elevators near the loading position.

It traverses on a central pivot and a single circular racer 14 ft. in diameter, and the platform is about 16 ft. 6 in. in length. A counterweight *D*, sufficient to balance the weight of the gun, is placed between the two elevators.

In the firing position, the centre of gravity of counterweight, and the fulcrum, on which the elevators rest, are nearly coincident, and are both in nearly the same vertical plane as the trunnions of the gun.

On the discharge of the piece the elevators roll backwards on the platform causing the gun to descend in a cycloidal curve, while at the same time the counterweight rises (at first with an increasing velocity). The centre of gravity of both the gun and the counterweight together, is also the centre of the circular part of the periphery of the elevators; this being the portion on which the elevators first roll after firing, it follows, that the common centre of gravity of the gun and counterweight travels backwards in a horizontal plane. And as this circular part is about a quadrant, the detachment is enabled to work the gun for drill purposes, or to place it under cover, from the firing position, with ease, the whole structure being in a state approaching to stable equilibrium. As soon however as the elevators pass off the circular arc on to the greater curve the leverage in favour of the counterweight goes on in an increasing progression, until it becomes sufficient to meet the utmost force of the recoil. Thus the recoil is absorbed without necessarily using friction, and it will be observed how this arrangement takes off that shock, and vibration, which proves so destructive to pivots, and masonry, in the ordinary carriage, and which has led to so much expense lately in making foundations strong enough for the platforms of heavy guns.

When the gun has recoiled as far as it will go, it is held in that position by a self-acting pawle, and then loaded under cover. The elevation can also be given to it in this position, if desired, as there is a trunnion pointer with segmental scale on the cheek of the carriage.

If the pawle is lifted the energy of the recoil (stored as it were in the counterweight) raises the gun into the firing position, its movement upwards being regulated by one gunner holding the handle of the friction band. Thus a dangerous and destructive agent is tamed, and turned into a useful servant.

When the gun is in the firing position it can be laid either with the usual sight, and in the usual manner, or it may be laid with my reflecting sight from below. In the former case, No. 1 steps off the shelf in rear of the gun on to another shelf at the side of the rail, he there can remain while the gun is fired, and the time taken to step from the one position to the other is less than that required on a dwarf traversing platform. If the reflecting sight is on, the laying can be checked from below.

In the latter case, viz: where the reflecting sight alone is used no one is exposed, and as the elevating screw in that case can be worked in front of the carriage and the traversing at the side of the platform, a new condition is obtained, viz. the power of following a moving object, and firing at it while the gun is actually in motion. In this case No. 1 does not require to guess the distance before the object passing his front, as in laying the gun on a dwarf traversing platform.

In this paper I do not go much into details, nor shall I describe any of the other carriages, feeling that a description of one class of carriage is enough to illustrate the principle which is common to all. By abstaining from this however, I must leave very interesting ground, as the whole question connected with siege guns must be left out.* In these the wheels are used for elevators, and in some cases the counterweight is dispensed with, when its weight would be inconvenient for transport. I must also leave untouched as belonging to this branch of the subject, the new conditions that these lighter guns would give in resisting the landing of troops covered by the heavy fire of ships—their use in covering the front of a permanent encampment, in siege operations, &c.

I have been engaged in the Royal Arsenal since the 13th of August in superintending the manufacture of a carriage, &c. suited for a 7-ton rifled gun. The government decided to test my invention by selecting that

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* See discussion on General Sir J. F. Burgoyne's paper on the siege of Borgoforte, June 1866 "Professional Papers of the Royal Engineers," Vol. XVI. p. 5.

application of the principle, which I proposed to apply to this class of gun, and required that I should produce a complete carriage, with every appliance matured for working the new arrangement. This has taxed my attention to the utmost. I conducted at my own expense an inductive series of experiments which were commenced in 1857–1858 with models, and which I carried as far as a 32-pr. 48 cwt. gun.

There is a great margin however between a 32-pr., and a 7-ton M.L. rifled gun. I believe I may confidently state, that in the history of mechanics a perfectly new principle has not before been applied, to control such enormous strains and weights with so small a series of experiments; on that account, if the approaching trial is satisfactory, I think it will speak well for the principle advocated by me.

Before finishing the description of what belongs to the carriage and going on to more important considerations, I shall briefly describe the reflecting sight already referred to, which is an important adjunct of the arrangement, although not necessarily always employed, being quite a separate invention. It consists of a reflector placed in front of the trunnions, and a fore-sight in front of the reflector. A line through zero on the fore-sight, and parallel to the axis of the gun, passes through two cross wires on the reflector at their intersection.

The fore-sight is graduated from zero downwards in yards, to the extreme range of the gun, and is set at an angle to correct the permanent deflection of the rifled projectile.

The field of vision is extended at pleasure by moving the eye. In laying guns I have observed that all men have not the same facility, although their vision is good in other respects. I attribute this to the slow action in many individuals of the muscles of the iris; their sight is impaired for the moment, and its correctness affected by the effort to focus on distant and near objects at once. I anticipate that better aiming will be obtained with my sight in many cases, as the back sight, or intersection of the wires is about the same distance from the eye, as it is from the fore-sight, while the object aimed at, is reflected in the same plane as both. This conjecture however remains to be confirmed by experience.

The carriage itself possesses a few advantages, but the real value of the system is to be found in the new conditions it introduces.

The advantages which belong to the carriage itself are merely such as that of removing injurious horizontal strain from the platform, and economizing labour in working the gun, by leaving the gunners to deal with only the difference between the weights of the gun, and counterpoise, instead of with the whole weight of the gun.

I shall now endeavour to indicate some of the applications of the system. Its relative value is to be estimated by comparing it with others; and in order to do so, I shall divide the subject under a few heads, that each point may be scrutinized separately, and the balance in favour of, or against the proposed system ascertained in each case.

I shall omit in this comparison some special applications, such as the use of my proposed gun pits, a method of mounting artillery made possible for the first time by the invention, its use in ships, in which case steam or compressed air is used instead of counterweight, also its application to heavy howitzers, &c. &c. as the limits of this paper will not admit of them.

The heads under which I invite discussion are the following:—

(1) Protection from vertical fire.
(2) Protection from direct fire.
(3) Lateral range.
(4) Economy in construction of works.
(5) Economy of life.
(6) Mark offered to an enemy, and power of being masked.

I believe the *first,* viz. protection from vertical fire is considered to be the weak point of my system, but it is only at a disadvantage in this respect when compared with turrets and casemates, which of course are very expensive; and there is this to be said for it, that the space occupied by the platform is smaller than that occupied by those of the present construction; the distance for instance between the traverses on each side of the gun and between the interior slope and rear of the platform need not exceed 21 ft. for a 12-ton gun; further,.this space can be reduced by contracting the top of the parapet and traverses. Vertical fire, moreover, is least to be considered, on account of its inaccuracy, and also (as those who have experienced it know) because a few traverses generally enable the men to avoid it.

Second. Protection from direct fire.

I take the liberty of quoting Captain Schaw, R.E., Professor of Artillery and Fortification, Staff College, on the question of Fortification:*—

"The great difficulty in all fortification, at the present, is how to protect the guns and gunners, and yet to give the fullest scope to their fire. In field fortification, barbettes and embrasures each have their advocates, and some even recommend blinded batteries. The last-named clearly are inadmissible for the same reasons that have been urged against timber blockhouses. Barbettes have been found, in the experience of the late American campaigns, and in our own experience in the Russian war, to be useless when the enemy's riflemen can converge an effective fire upon the gunners; they are too much exposed when crowded round the gun to serve it under such circumstances. Embrasures restrict the lateral range of the gun, weaken the parapet, are open doors to let the enemy's shot into the work, and targets for him to fire at, and are soon destroyed and choked up by the combined effect of the enemy's fire and the explosion of the guns fired in them; moreover, they give but little real protection to the men serving the gun from the enemy's artillery; but when supplemented by mantelets they do protect the gunners from rifled small-arms, and are, therefore, a necessary evil at present."

Also from a paper of mine,† June 3, 1867:—

"The protection which my system affords is of a character that has not as yet been given to artillery. In working guns, two conditions which usually conflict with one another have to be obtained; the one is to make the gun formidable to an enemy, and the other is to have at the same time both it, and the men working it, as little liable to injury as possible.

"The first condition is obtained by having appliances that expedite aiming and loading, and also those which enable each gun to traverse as large an angle as may be required. The second condition has until lately received very few improvements beyond the old and well-known method of the embrasure, &c. However, improved casemates, the contraction of ports by the use of armour-plating, cupolas, and

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* Transactions of the Royal United Service Institution, Vol X. p. 446.

† Ibid., Vol. XI. p 251.

Lieut. Bucknill's ingenious system of firing through a false parapet or screen, &c., &c. have each and all their advantages for certain positions, but with one exception viz. the cupola, they all curtail the power of the gun by contracting its free range; and, therefore, with that exception, what they gain in safety they lose in efficiency, where range is required. My system has the happy peculiarity of combining these two conflicting elements in a high degree.

"The embrasure necessitates the breaking and weakening of the parapet. It also restricts its thickness for a given number of guns, not to speak of the mark which these embrasures present to the enemy. Armour-plating on land works, at great expenditure of money, reduces these evils considerably, but by no means entirely removes them; so that on reviewing the position of my invention in this respect, I feel my only competitor to be, the cupola. What can be said in favour of the cupola nearly applies to my system. We are equal in our power of traversing; and in the matter of protection, you will have to decide, after I have stated the exposure in each case.

"The cupola is always a mark, and is always exposed, and to very heavy ordnance, its invulnerability is still problematical. Its port, though small, is liable to be hit for a certain time. Its gun detachments are annoyed, if not hurt, by the concussion of heavy projectiles. It is of enormous weight, and to avoid a shot in the port, it requires to turn its cheek on the enemy after each round, involving a good deal of labour. On the other hand, my gun, and the men serving it, are absolutely protected from direct fire, except that the gun and one man are exposed while aim is being taken.

"When the gun is up to be aimed, it is more exposed than the cupola gun, but the moment it is fired, it is safe.

"If a screen be used, the enemy cannot see whether the gun is up or down; I thus draw his fire, the correctness of which must be materially affected by having no definite object to aim at.

"The best way perhaps of putting the question is this: Would gunners prefer to be shut up in an iron box, only penetrable by the enemy's shot through the port, but liable to injury, in other parts; or would they prefer to fight their guns in the open air, and all under cover, except the man who aims, he being only exposed for a very short time and partially protected by the massive breech of the gun? Are the chances of injury greater in my case, where the gun is only liable to be hit during the few seconds required to lay it, and is in absolute safety the moment it is discharged—or, as in the other case, where the cupola remains a constant mark for heavy projectiles, and runs a continual chance (though a small one) of receiving a shot through the port itself?

"It is obvious that the possibility of dispensing with a parapet without losing command of the front of the battery, would give an advantage of an important kind. This advantage I seek to obtain in its greatest degree by employing gun-pits, in which all the vital parts of the carriage remain below the level of the surface, and the gun itself is only exposed when it is going to be fired.

"For coast batteries liable to be opposed to the heaviest artillery in ships, a very strong work is now absolutely required to protect the guns from the terribly destructive effects of modern projectiles, which have a penetration far beyond what was dreamed of when most of the existing fortresses were built; and as accuracy of fire has increased, as well as its power, the guns cannot be mounted *en barbette*.

"In order therefore to be efficient, coast batteries must be of great strength, and proportionately expensive, especially when iron is used in their construction.

"I wish this to be borne in mind, while I point out that by taking advantage of the natural undulations of the ground, scarping down the rear of hillocks to make them into batteries, and applying the skill of our military engineers to use whatever nature has supplied in each place, many positions might be defended on my system from the attacks of the heaviest artillery, at a small per centage of the cost which is now required to construct batteries with iron embrasures, cupolas, &c.; and that notwithstanding the economy of these works, they would be probably as invulnerable as their more expensive rivals."

Fig. 2 shews a method of laying a Moncrieff ground platform on insecure or marshy ground. The absence of horizontal strain enables me to dispense with concrete foundations, &c., and in most cases it would be sufficient to lay the ground platform on a thin layer of gravel carefully leveled for the purpose.

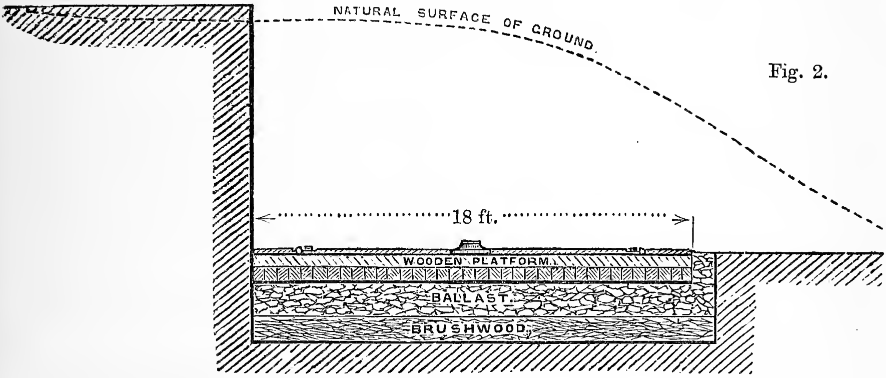

Fig. 2.

Third. Lateral range.

The lateral range of the guns is the same as those in a cupola, this quality would be valuable in guns on the face of a work, and of course still more so on salients; in fact, it would make a few guns as valuable as a much larger number mounted in the usual manner.

Colonel Gallwey, R.E., comparing a two gun turret with guns behind embrasure shields,* writes,

"We may ask then, admitting the above comparison, If two guns in a cupola can cover as much ground as six mounted behind shields, what would be the number of guns in ordinary earthen embrasures that would produce an equal effect, looking at the superiority of protection as well as range controlled? The answer might be: If it be admitted that one gun behind a shield is worth three behind ordinary embrasures (as it certainly would be), then the two in the cupola would be worth eighteen in earthen embrasures, and this estimate is not extravagant if it be closely examined."

Fourth. Economy in the construction of works.

The failure of ordinary embrasures on the one hand, and of barbette batteries on the other, arising in the former from weakness of the parapet, and in the latter from exposure of the gun and detachment, is due to the increased penetration and precision of modern ordnance.

The change in the conditions of fortification inevitably produced by this

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* Professional Papers, Royal Engineers, Vol. IX. p. 45.

increase of power, and accuracy in guns, is of a very serious character. There is no way of meeting that change except by the use of iron. I need not dwell on the objections to the general use of this material for land defences. It must be borne in mind that those who advocate its use do so because it is the only alternative that has presented itself. I need only remark that a two 12-ton gun cupola completed costs, exclusive of the guns themselves, about £15,000, and the price of a sufficient armour shield is not yet decided on.

The expense of making sufficient defences on the system I propose would almost be defrayed by the interest of the money required to be sunk in making thoroughly efficient iron-plated works. The saving is therefore prodigious and such as would be of the utmost consequence, and would even seriously affect the resources of the wealthiest nation; and as in war, cheapness has often the same meaning as possibility, it is difficult to over-estimate this feature.

In the event of my system partly supplying the place of iron-plated land works, I hope the country will not forget what it has been relieved from. With mature deliberation, and after every other resource had been exhausted the government have been forced to adopt iron as the only material giving satisfactory results. It would have been false economy indeed, to have done otherwise. To have left vital positions on our coast insecure, whatever might be the expenditure required to make them safe, would have been a grave error, and the system now proposed, would not in every case supersede its advantageous use: it might undoubtedly however, be employed in conjunction with the more expensive batteries, and in certain positions would be preferable, while the expense would be reduced materially whenever it could be applied.

Independent however altogether of the consideration of the first enormous expense of building iron-plated strongholds, there are important military considerations to be taken into account in connexion with them.

Such permanent and complete works as I refer to, when once made have to be taken care of, and garrisoned; they must always remain a source of anxiety, and a continual drain upon our resources in men and *matériel:* a certain number of such strongholds are necessary, but they cost vast sums to complete them, and much to maintain them, and after all if iron casemates and embrasures alone are employed they may be found at some future period insufficient to cope with improved artillery.

For these reasons it will no doubt be considered inexpedient to multiply the number of such works. What is then to become of secondary positions of importance? Must they be left with defences that will crumble before the new artillery of ships? Are English soldiers to have the forlorn duty of fighting armour-clads from behind crazy embrasures? Or, are those positions to be left to the mercy of any adventurous privateer? I sincerely hope that the system now advocated may to some extent prove a satisfactory solution to these questions. Captain H. Tyler, R.E.,* alluding to the requirements in future fortifications says,—

"The great problem to be solved is, how to obtain all these advantages with economy—not such economy as would deprive the works constructed of efficiency,

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* Professional Papers of the Royal Engineers, Vol. IX. p. 95.

which would not be economy at all—but such as will make fortification so to speak, possible, and will afford to it a maximum of efficiency, at a minimum of expense.

"In endeavouring to find the solution of this problem, I shall purposely avoid laying down anything that can be called a system. As is well known, systems have already been too much the bane of the science. Now more than ever, systems of fortification must give way to principles of construction; and (if the word system be used at all) to systems of defence. No two fortresses ought to be alike; but each work, and each collection of works, should be adapted to the purposes, strategetical and tactical, which it is intended to answer; to the pecuniary means and material, at the disposal of the engineer; to the exigences of its site; and to the circumstances of its topographical position."

If the system this paper discusses be thoroughly developed, it might be considered sufficient in many cases of coast defence to devote attention to perfecting the *matériel* of a powerful artillery, with every appliance that could make it efficient. This artillery would be stored safely at points where attack may be expected.

If this course were taken, an enemy would no longer be able to avoid our defences by knowing exactly where they are, because we should have the power to extemporize them if required. But considering the suddenness with which wars are now decided, it would be expedient to study the conditions in each case very carefully, and prepare the ground for the reception of its armament, by leveling down, or filling up, and forming the batteries as far as considerations of economy and expediency required; securing near plantations of copse for gabions and fascines, &c., &c. leaving only such work to be done, as could be completed with short notice.

I go so far as to say that government might have in its possession private reports from a variety of officers for each position. The data given to these officers on which to found their reports being the amount of artillery and stores set aside for a certain position, they might be required to give detailed estimates and plans for putting that position in such a state that, say two batteries of siege artillery, a company of engineers, and 3000 labourers could complete the work and mount the guns in a week, satisfactorily estimating time and expense. I venture to make these suggestions because they are particularly applicable to the kind of earthworks now advocated, which would have in many respects the strength of permanent works, with the inexpensive character of temporary ones.

Fifth. Economy of life.

I rejoice to think that there is reasonable cause to expect a smaller waste of life in gun detachments. The power of any arm in relation to another will be determined to a certain extent by this condition. The late improvements in small arms I do not think have been in favour either of cavalry or artillery. The exposure of gun detachments in defensive batteries under the fire of new rifled artillery has not been much tested since the latest improvements—immense precision and penetration coupled with the perfection of percussion and time fuzes and the construction of shells—would lead one to expect heavier casualties. Where iron is used of course the proportion is altered, but even in that case the nuts and bolt heads have shewn a disagreeable propensity to fly about, and the exact injury from concussion in cupolas where a heavy shot hits fair, is still a matter of dispute.

None of these conditions affect the gunners in the present case, occupying as they do the defiladed space in rear of a high interior slope, and with all the advantages of mantelets but in a higher degree.

The *sixth* or last head, viz. "Masking" is one which perhaps is not likely to be appreciated at first sight. No doubt it is an advantage which has not hitherto been enjoyed after guns had once opened fire; and therefore experience does not directly bear on it. I trust, however, that practical officers will agree that the proposed system possesses no small advantage in this respect over present ones, where guns are either in embrasures, in casemates, or *en barbette*. It would be rather difficult I conceive to open a correctly directed fire on a line of batteries which presented nothing to the eye, and which had not a mark of any kind to guide the aim.

If the ground were judiciously chosen for such batteries, it would be very difficult indeed to determine the exact position of the guns, and very unsatisfactory work to direct a fire on them.

I cannot illustrate this better than by begging my readers to recollect the case of the Mamelon at Sebastopol, which fell by assault after its batteries had been silenced. I watched very carefully the sort of fire, which gun by gun shut up this work until there was only one left to answer the bombardment, and feel justified in saying that had it not been for the embrasures, all the artillery we had in position on the allied front would not have produced the same result in the same time; and from the way the French fell back after their first attempt, I am convinced the assault would have failed without regular approaches had there been a few guns to sweep the glacis.

As another illustration. Suppose the entrance to a harbour, the mouth of a river near a large town, or other narrow waters had to be defended against ships. If a few powerful guns were judiciously placed in "Moncrieff" batteries, connected and supported by trenches for infantry, could anything more embarrassing be imagined for ships, than to receive a deadly fire from the most peaceful looking hillocks, and when they looked for their enemy, to see no mark of his position except a cloud of white smoke passing gently to leeward, until their attention was distracted by the same phenomenon in some other unexpected quarter?

In connexion with this subject I beg also to direct attention to a proposal which becomes possible, viz. that of using transparent screens.

These screens would be painted the colour of whatever happened to be the background of the battery. They would be made of the lightest materials, and would be used to deceive the eye of an enemy when he discovered the exact position of a gun (which however would very seldom be the case). A screen of this kind through which the gun could be laid, but which would effectually obscure the view to an enemy, has the following recommendations: it can in a moment be replaced. It forces the enemy in order to have the chance of hitting the gun in the firing position, to waste his fire all the time it is down, and as that fire is utterly thrown away while the gun is down in the loading position, it follows that an enemy besides having to overcome the very great difficulty of hitting the proper point at all, has to take the chance of the gun not being at that point when he fires.

The officer by watching the character of the enemy's fire, and selecting the best time to lay his own gun, might make the enemy's task nearly hopeless.

I have here to offer a suggestion which relates to this view of the question.

In certain positions where a line is not exposed to enfilade, it might be of advantage to have the platforms running on trucks on a line of railway in rear of an extended parapet.

A proposal of this kind was made some years ago for the purpose of defending parts of the coast. I need not remind my readers that such a proposal is impracticable, as the strain across the line with modern rifled artillery, would tear up the rails. The case is now altered however, as far as that is concerned, as the interposition of a moving fulcrum between the gun and platform would enable ordinary rails to carry a gun in action, and the whole weight of a 23-ton gun platform, and counterweight would be under that of a heavy locomotive (60 tons). The guns could therefore be pushed by their detachments to any point of the parapet at which they might be required without being exposed to view.

To recapitulate shortly what has been said, I submit that my proposed system is calculated to produce, to a certain extent, the following results:—

It absorbs the recoil in such a manner that it is turned to useful account instead of acting as a destructive force.

It takes away horizontal strain from the platform.

It gives security from direct fire.

It increases lateral range.

With equal efficiency it effects large economy in the construction of works for coast defence, &c.

It economizes life, and it makes batteries more invisible, and therefore more easily masked before action, and more difficult to attack in action.

For thirteen years great attention has been given to the improvement of ordnance; in no country has the subject engrossed more attention than in England. The best mechanical skill which the nation possesses has been brought to bear on it, and with what success no one knows better than the members of this Institution.

I have watched its progressive advances for ten years with a special interest, and each improvement has acted as an additional stimulus to the work this paper discusses. Impressed more and more, with the urgent need of some method of meeting the increasing penetration of projectiles, I struggled first with the mechanical difficulties in my way, and latterly with the not less formidable difficulty an inventor has to experience, viz. passive resistance to new ideas.

I hope, however, that I have now, to some extent, emerged from both.

Probably the eagerness with which improvements in artillery have been pursued, has had some effect in withdrawing the attention from the new conditions, that these improvements themselves imported into the land service.

The problem presented itself most urgently, and in its most formidable aspect, to the navy, and large sums have been expended, and are now being spent in solving it for this service.

The land service has been content to follow in the wake of the navy, and the country is at this moment on the brink of a gigantic expenditure for iron fortifications.

The imperative necessity for improved works, pointed out by Engineer Officers, who have clearly seen the dilemma approaching (some of whom are quoted) is at last acknowledged on all hands, and there appears nothing for it now, in order to protect our guns and gunners, but to borrow the unwieldy armour which is necessary for ships, and clothe our batteries on shore with the same expensive material.

I cannot help thinking that some method, such as mine, would in a great many instances fulfil all that is required, and even occasionally enjoy advantages of its own, independent of economy. These remarks apply with equal if not greater force to our distant colonial possessions. I trust, at any rate, that whatever amount of success may attend the approaching trial, I may be permitted to develope a system which promises to be successful, and which, if it does succeed, will save millions to the country, and, what is of still more importance, will place our defences on a more satisfactory and efficient condition than even the most expensive of those methods that have been proposed.

Annexed is a letter from General Simmons, C.B., Director of the Royal Engineer Establishment, Chatham, dated 18th March, 1867, criticizing in a very lucid manner the results of my experiments at the date it was written, and the objections which, at that time, were supposed to stand in my way.

My dear Sir,

I have been looking lately with much interest at the description and plans of your proposed system for raising guns, so that they may fire over a parapet, and in their recoil, fall down below it, so as to be completely concealed from view. The object, the solution of which you have proposed to yourself, is one of very great importance to the service, and one which, before I knew you had turned your attention to it, had occupied mine so much, that I had tried to direct the attention of my brother officers to it, and I have also suggested it as a problem requiring solution to some mechanical engineers, thinking it might probably be accomplished in a convenient manner by hydraulic power.

The importance which I attach to an invention of this nature is very great. By it the gun is effectually concealed when not in action, and is kept under cover for the greater part of the time it is in action. The gun, when placed behind a parapet or epaulment, or in a pit, presents no object upon which an enemy can direct his fire; the importance of this, when exposed to rifle guns (both small and great), cannot be exaggerated, and moreover, it disposes of the difficulties attending the embrasures in earthworks, whether for attack or defence. These difficulties are very great:

(1) The embrasures present a fixed and constant target upon which guns may be laid.

(2) Embrasures weaken a parapet, and, as usually constructed, present the most favourable conditions for bursting shells fired with percussion fuzes, the thin part of the merlon affording just resistance enough to fire the fuze.

(3) The gun is always more or less exposed to injury from direct fire.

(4) No revetment has yet been found for the cheeks of embrasures, which is not readily destroyed, either by the fire of their own guns or those of the enemy, thus shutting the guns up and necessitating repairs, which are among the most dangerous duties of the soldier.

Various means have been proposed for palliating these evils, such as fixing iron shields, revolving cupolas or towers, and many other schemes which lessen the efficiency of batteries, by restricting their lateral range, and, all of which that I have ever seen, are exceedingly costly, and after all are only a very partial cure for the evils complained of.

It appears to me that the system of loading guns below the parapet, which may be of earth of any thickness, and therefore very difficult to destroy, and only bringing them up to an exposed position at the moment of firing, gets rid of all these difficulties.

Of course any system which may be proposed for this purpose must have objections of its own; but I confess that your scheme is more free from objection than any I have seen; and having given it my best attention, I see no reason why it should not succeed with guns of any weight, however great, that are ever likely to be introduced into the service. If successful, it will save an enormous outlay to the country in its fortifications, which, in these economical days, is almost more thought of by those who control expenditure, than efficiency,—at the same time that it will add enormously to their practical value when submitted to their true test by an enemy's fire.

Your scheme appears to me to present no mechanical difficulties but what might easily be overcome, and it gets rid of one great mechanical difficulty which has not yet, I believe, been solved with guns as now mounted on the most approved pattern of carriage and traversing platform. I allude to the horizontal strain brought by the recoil upon the various parts of the carriage, platforms, racers, and traversing bolts. This action is a very serious difficulty with guns on traversing platforms, whereas, according to your system, there will be little or no tendency to force the turn table or traversing platform back.

You may expect objections to be taken to the weight and bulkiness of your counterpoise; but I don't think they need disturb you, as, when once the gun is mounted, this counterpoise actually diminishes the labour of working the gun, forming as it were a reservoir of power to run it up; and with regard to its bulk, you may reduce that considerably by the employment of lead, cast in ingots, so as to pack very closely, and still be manageable on the rare occasions when it may be necessary to dismount the guns.

I see no difficulty whatever in constructing a proper turn-table, for, after all, the weights to be dealt with are not greater than are to be seen daily on turn-tables on railways, and absolutely nothing compared to what may be seen in operation on board ship with cupolas and revolving towers.

One great objection which may be raised to any system of this nature is, that it is not compatible with the protection of the guns from vertical fire. The question between guns protected in this way and others in casemates is therefore one of the relative danger of horizontal fire at embrasures and vertical fire. For my own part, I should not hesitate to choose in favour of the system as worked out by you, the gun being protected on its flanks and rear by traverses, which would reduce the danger to a minimum.

There are many situations, however, where casemates are inapplicable, and, when opposed to shipping there is very little danger to be apprehended from vertical fire. In such situations I have no hesitation in saying, that some plan such as this of yours, if it succeed, will be an immense improvement on anything we now have, and will be invaluable. I hope, therefore, you will persist with your system, and get it thoroughly tried.

I am, &c.

Woolwich,
May 4, 1868.

Captain Moncrieff's carriage for 7-ton M.L. gun, went through a preliminary trial on the above date, in the presence of several officers.

The following are the results:—

Rounds.	Charges.	Remarks.
	lbs.	
1	22	Blank.
2	7	With 115 lb. shot, recoil about one-third of the platform.
3	14	" " half "
4	18	" " well up "
5	22	" " nearly up "

In all these rounds the gun on being released, recovered its loading position with the greatest ease, being completely under the control of the man at the break.

The carriage was not quite finished, and one or two trifling alterations in the small gear suggested themselves. The rack not being fixed, the traversing gear was not tried. On the whole the experiment appeared perfectly satisfactory to every one present.

E. WRAY, Colonel, R.A.

C. R. F. BOXER, Captain, R.N.

ERRATUM.

p. 18, line 23, *for* "Dupuis," *read* "Dupin."

HINTS

FOR THE

APPLICATION OF SHRAPNEL SHELL.*

BY MAJOR-GENERAL W. B. GARDNER, R.A.

It may be objected that the examples quoted, have reference to an obsolete style of manœuvring, and do not apply to the modern training and arms of infantry. Let us then briefly consider in what form the leading infantry of the continent, or that which most nations take as a type and model, is likelv to present itself as an object for practice. The following description is taken from the pages of the "United Service Magazine," and has reference to the manœuvres at Chalons. The writer says, "A shallower formation of the line of battle, with greater intervals between battalions; a more general use of oblique instead of square movements; frequent use of an increased pace, and no fixed right or left. The whole of the troops will be on more extensive ground when first engaged, and as the field is larger, therefore greater rapidity will be required than formerly, in order to turn a flank, or to concentrate on any given point. In whatever manner battles will in future be fought, it seems tolerably evident that close formations and heavy infantry drills are out of date, and that light infantry drills are essential, not only to enable the soldier to use with the greatest possible effect the improved weapons which have been put into his hands," &c.

Here then, in a few words, is exhibited the modern idea of a perfect infantry attack—shallow formations—light drill—speed. We know, however, that column movements cannot be altogether dispensed with, neither can large bodies of infantry be moved with great rapidity, but breech-loading arms will give confidence and power to lines and skirmishers; infantry fire will be greatly multiplied; and if infantry are allowed with impunity to close upon a battery, it must speedily be silenced. But the artillery must deal with them at a distance beyond 500 yards, and must be prepared for "shallow formations" and skirmishers; and to this end our chief hope lies in well-served shrapnel, such shrapnel as shall be effective at any distance up to 2000 yards, and against any formation, column, line, or skirmishing order.

Now, as regards the instruction in the use of this projectile, a few hints are offered.

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* Continued from Vol. V. p. 425.

The recruit begins with case shot, at ranges from 50 up to 300 yards; and at a target 6′×100′, he carries on practice, at first slowly, and then rapidly; and, if possible, over smooth, hard ground, and over soft, or rough ground.

We are apt to forget the value of case shot; here are instances.

On the retreat of the Duke of York from Dunkirk, in 1793, the late Lieut.-General Sir Wiltshire Wilson, R.A., fought his two light six-pounders in such a way as to save the garrison of Nieuport. In consequence of the country having been inundated, the French were compelled to advance along a dike about thirty feet wide. On this, Wilson placed his guns and discharged 113 rounds, principally of case, as rapidly as possible. The French were driven back.

And Waterloo as previously noticed.*

The next step in instruction is to shew the recruit that shrapnel is a combination of case and common shell; a few shrapnel are laid on the ground and burst, and the dispersion of bullets and splinters noted; and if considered desirable, and in order to make a contrast between shrapnel and common shell, a few of the latter may be burst in the same way, and the range of the splinters ascertained.

Figs. 1 and 2 may represent roughly the action of common shell and shrapnel burst in flight.

Fig. 1.

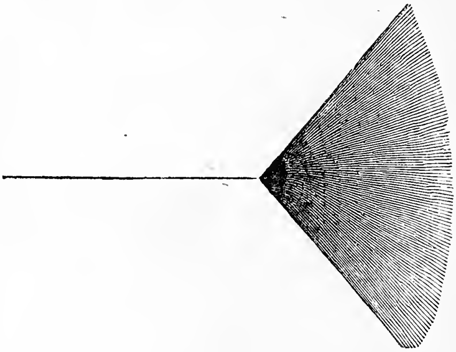
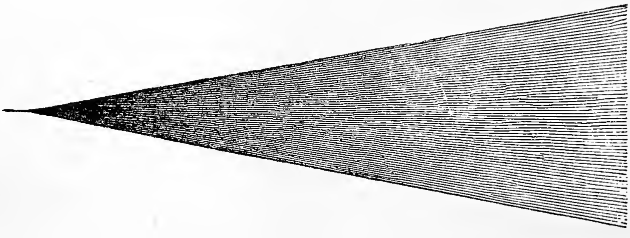


Fig. 2.



These preliminary matters having been settled, the recruit may proceed to practice, and he must be taught to rely on his own observation of the effects produced on the target, as seen from the gun, the range being unknown, and all communication with the range party interdicted. The number of observers, however, should be as large as possible, in fact this practice should be the true artillery judging distance drill. The range party also should be large, and under charge of an instructor.

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* Vide Vol. V. pp. 400, 421.

To simplify matters and render the effects clearer, we will, in the first instance, suppose the practice to take place over smooth water, and with a light wind blowing across the range.

A certain time, say four seconds after firing, a faint cloud of smoke appears over, in front of, or behind the target, indicating the point of rupture of the shell, i.e. where the action of case shot commences. Fig. 3.

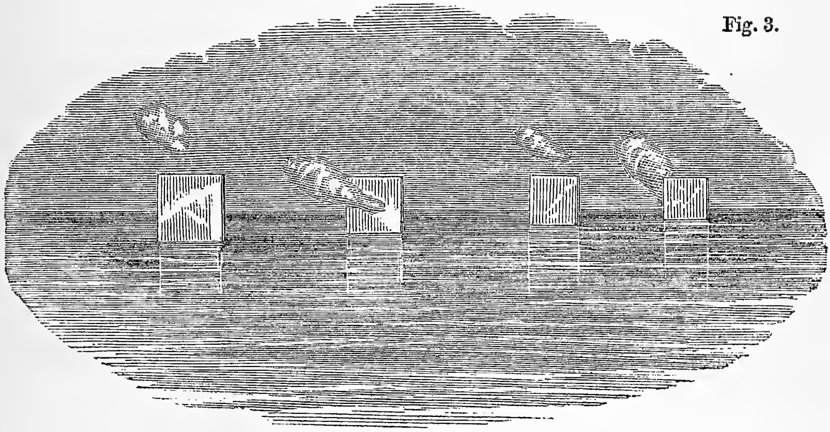


Fig. 3.

These are not hypothetical cases, they have occurred thousands of times, and will occur doubtless again when this nature of ammunition is used.

There are then three points for observation; first, the point of rupture, second, the line of foam or spray, third, the target.

A close observation will shew that the figure of the foam is oval.

We will select some examples; (1) the smoke above the target, the foam just on this side of it, Fig. 4. By reducing elevation and fuze we may see the smoke lower down on the target, and the white line of foam

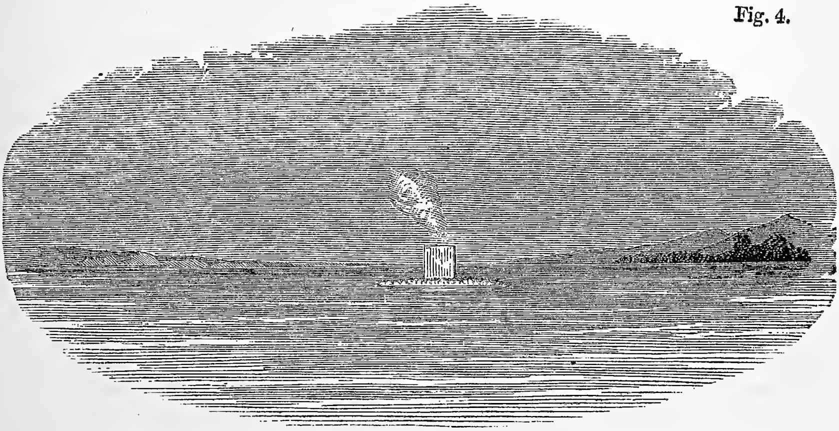
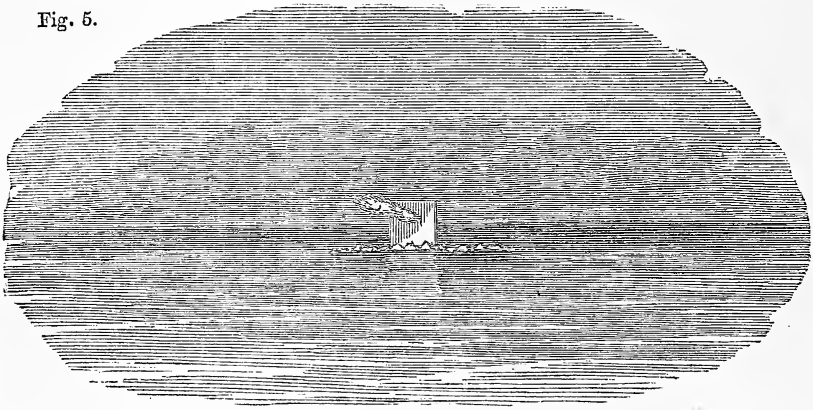


Fig. 4.

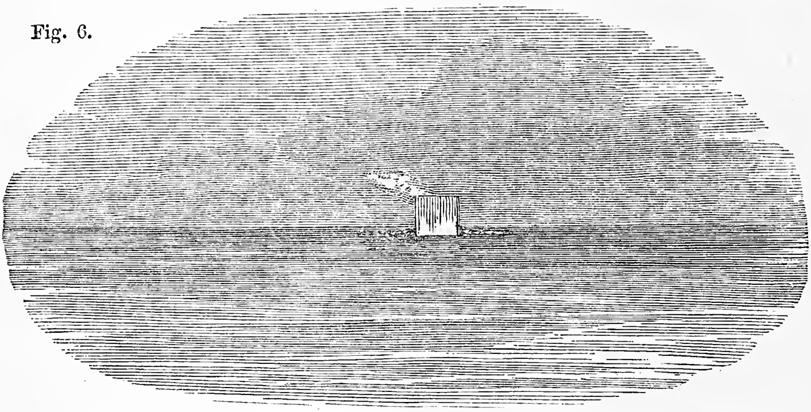
on this side of it; in this case the target will be partially observed. This practice is very deceptive, leading to the idea that both elevation and fuze are all that can be desired, when in point of fact no effect whatever is produced on the target. Fig. 5.

Fig. 5.



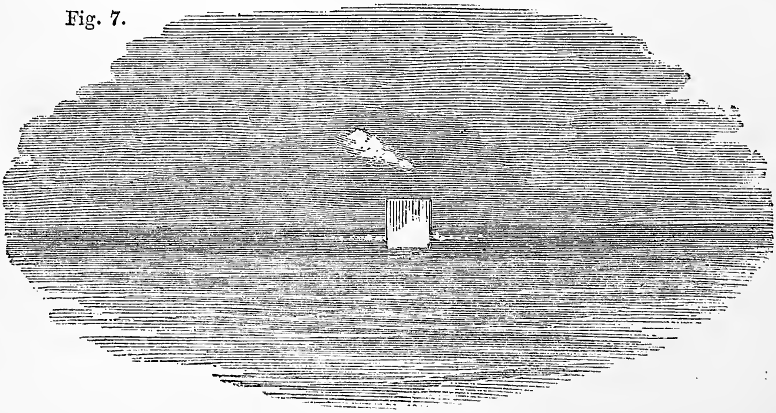
Here then, by an alteration of fuze and elevation (Fig. 6) we may see this

Fig. 6.



effect. Another round fired with increased elevation and longer fuze, shews the line of foam beyond the target. Fig. 7.

Fig. 7.



Lastly, we may obtain this result, the upper part of the target slightly obscured by smoke, and the foam divided, part appearing on this side of the target, and part on the other; splinters are seen to fly off, and the patter of bullets may be heard. Fig. 8.

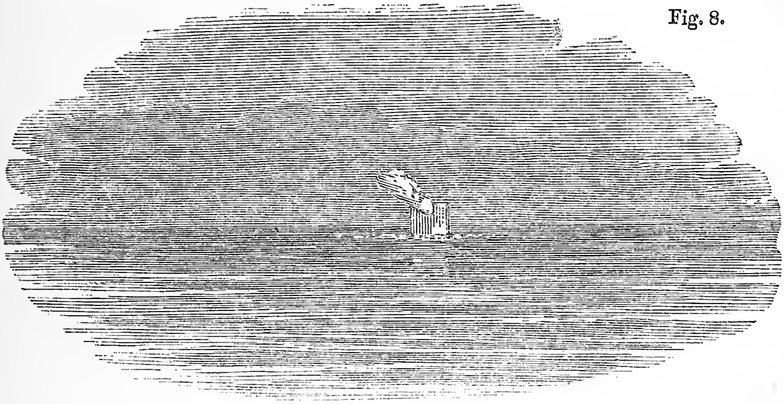


Fig. 8.

Viewed from alongside the target, all this practice would appear as follows (1) a short burst, no spray reaching the target. Fig. 9.

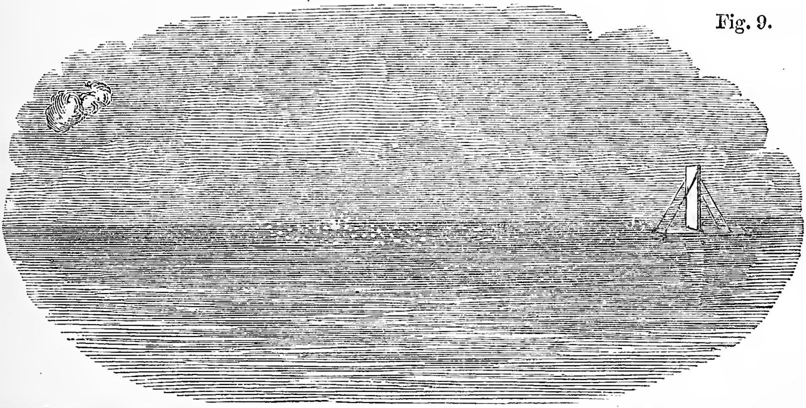


Fig. 9.

(2) A longer fuze, splinters and bullets carried beyond the target, no effect produced. Fig. 10.

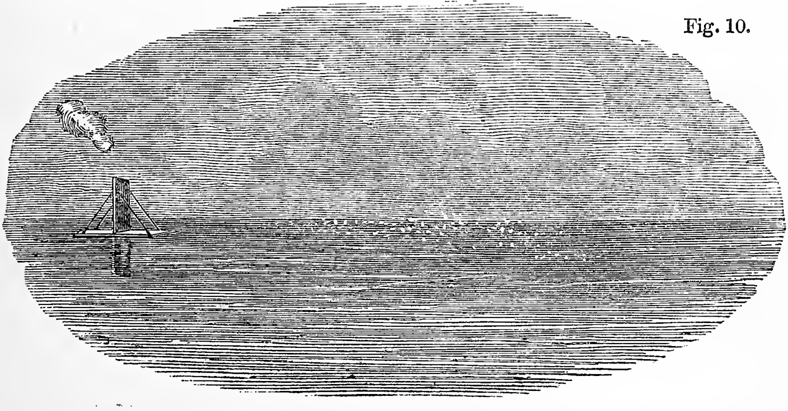
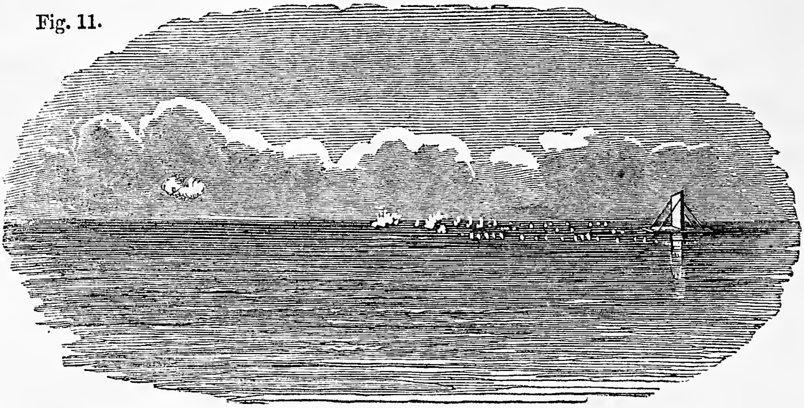


Fig. 10.

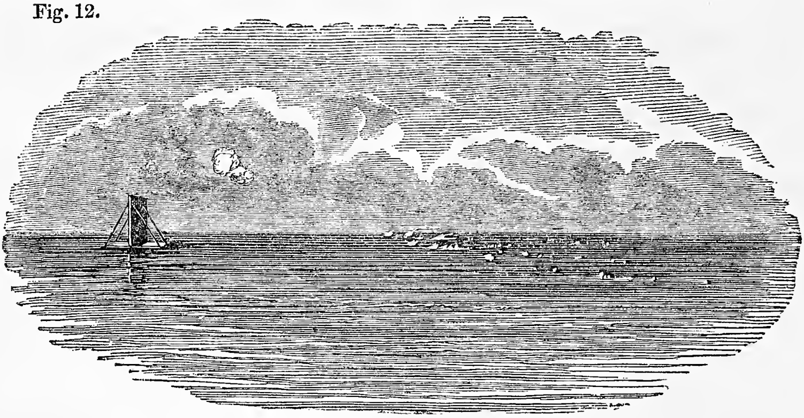
(3) Here we have evidently reduced elevation and fuze; no effect produced on target. Fig. 11.

Fig. 11.



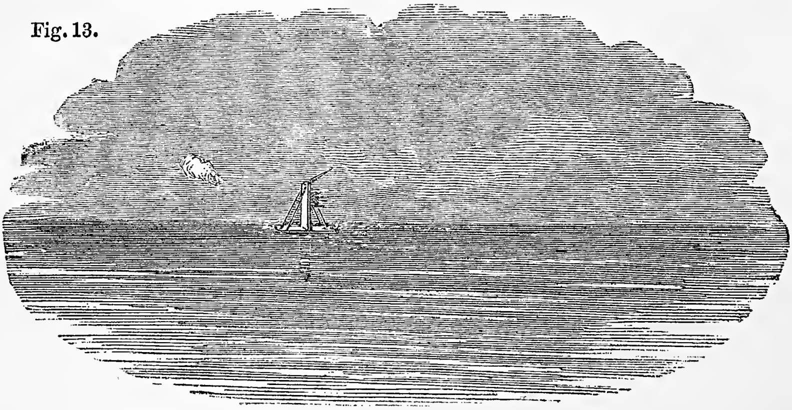
(4) Increased elevation and fuze are shewn here. Fig. 12.

Fig. 12.



Here we have the combination of fuze and elevation we require for producing effect upon a single target; splinters are knocked out, stays are cut, and the whole structure oscillates. Fig. 13.

Fig. 13.



The recruit is now supposed to be able to appreciate, with some degree of accuracy, the height of the point of rupture above the plane, and also the horizontal distance, either in front of, or behind the target, at which the shell may burst, when firing at a single target.

We will now suppose targets of other dimensions, and representing different formations of troops are to be fired at. First, line; our object should be now to burst the shell rather high and short of the centre, and we should be quite contented if we observed faint marks of bullets on this side of the target.

Figs. 14, 15, represent front and side views of this practice.

Fig. 14.

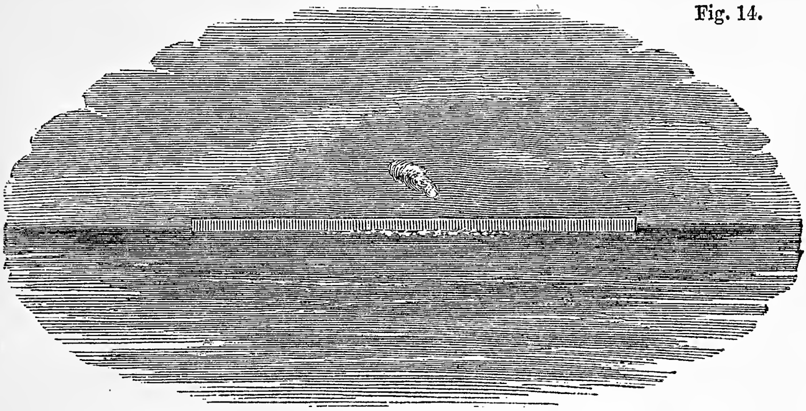
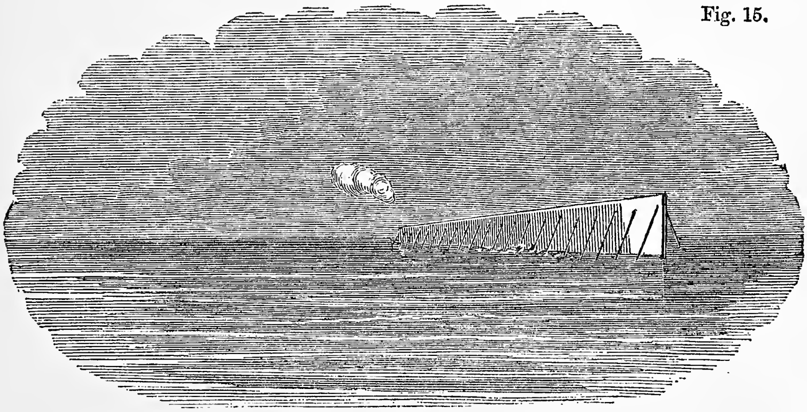


Fig. 15.



The next formation is column. In this case we endeavour to burst the shells about two or three feet above, and from fifteen to thirty yards short, according to the breadth of the column. If grand divisions are represented then fifty yards short. Figs. 16, 17, represent front and side views of targets in column.

Fig. 16.

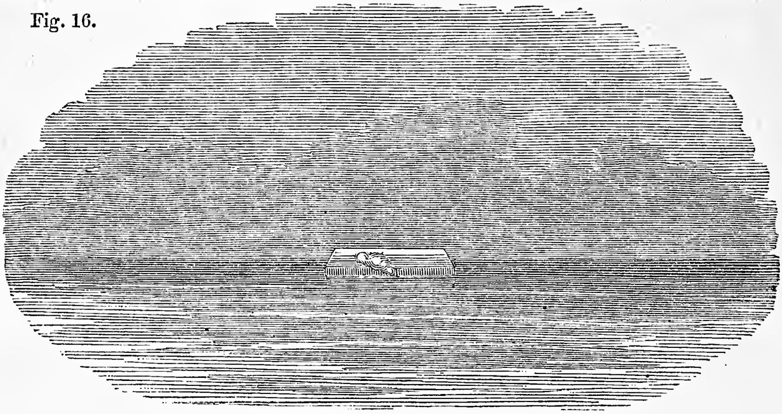
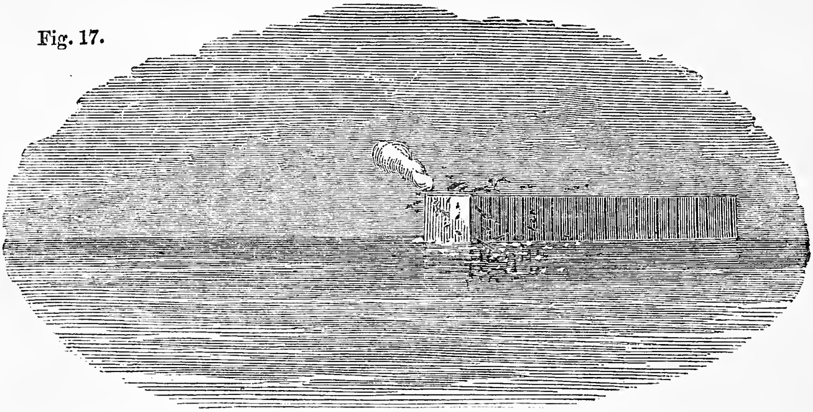
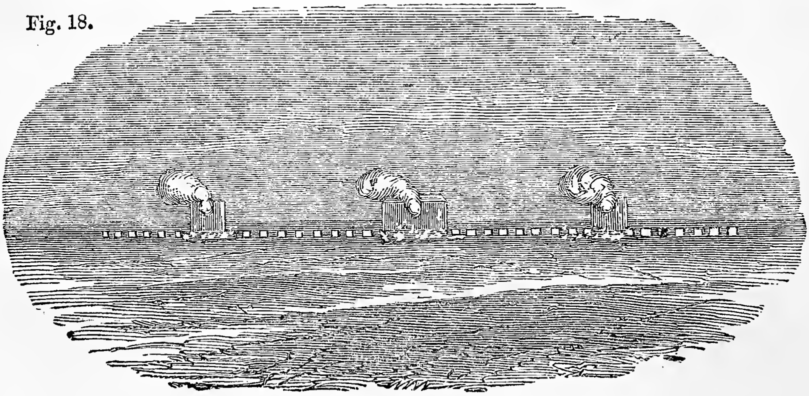


Fig. 17.



The next formation is very difficult to fire at with effect, a regiment advancing, covered by skirmishers. The targets representing the latter are 2′ × 3′ and 5′ or 6′ apart. The best plan is to fire rather short, but low, and in the direction of the supports. See Fig. 18.

Fig. 18.



All the foregoing cases have reference to time fuzes. If percussion fuzes are used, then we must fire directly at the foot of the target, and should the ground be hard and smooth, and the fuze arrangements perfect, we shall then see some such result as is sketched in Figs. 19, 20, namely, the bottom of the target obscured by smoke, and the earth, stones, or mud knocked up by the splinters, visible beyond the targets.

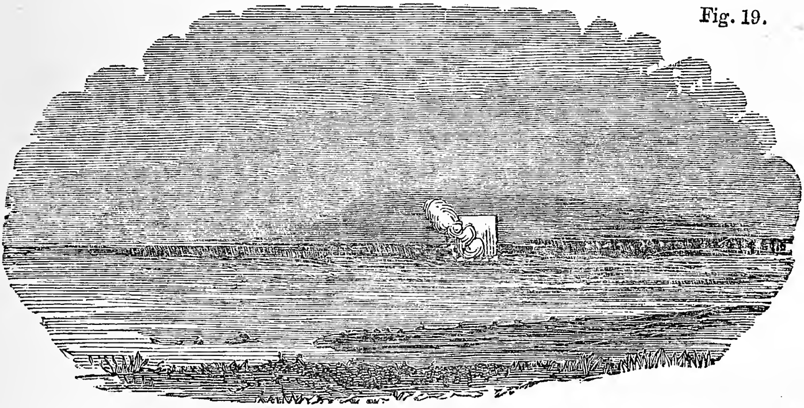


Fig. 19.

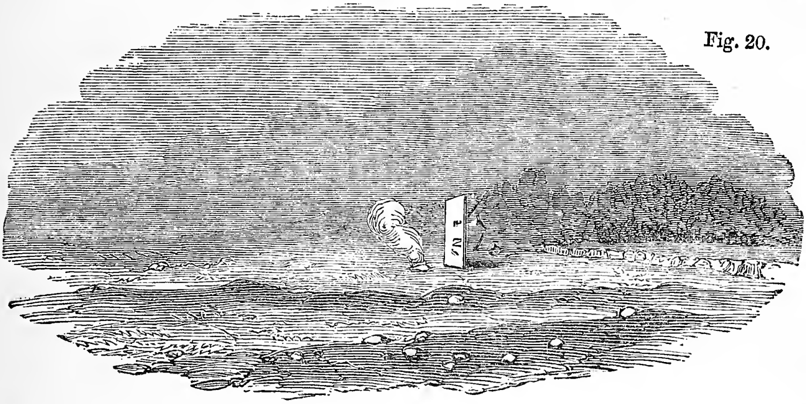


Fig. 20.

We have hitherto taken the simplest view of the case. Let us suppose the wind blowing either from us, or towards us, as in Fig. 21, the

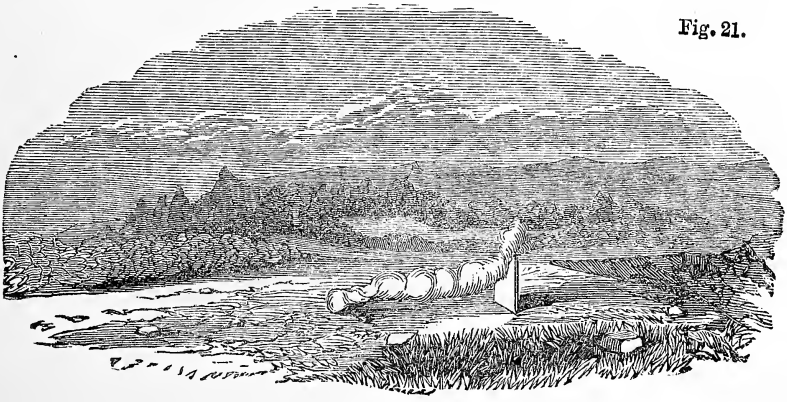
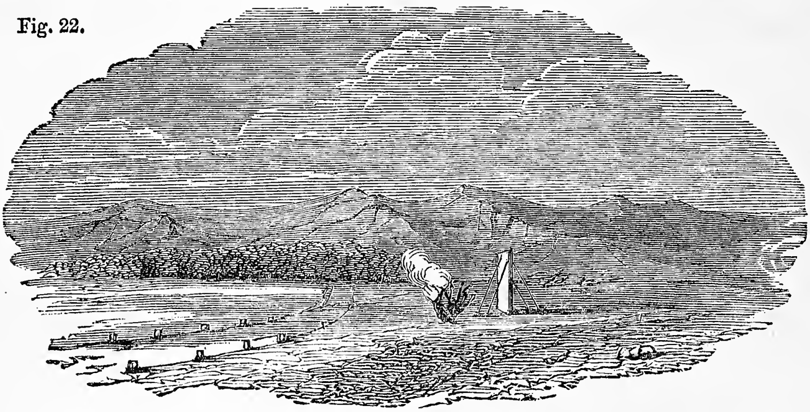


Fig. 21.

chances then of hitting the foot of the target will be materially diminished; the view is indistinct.

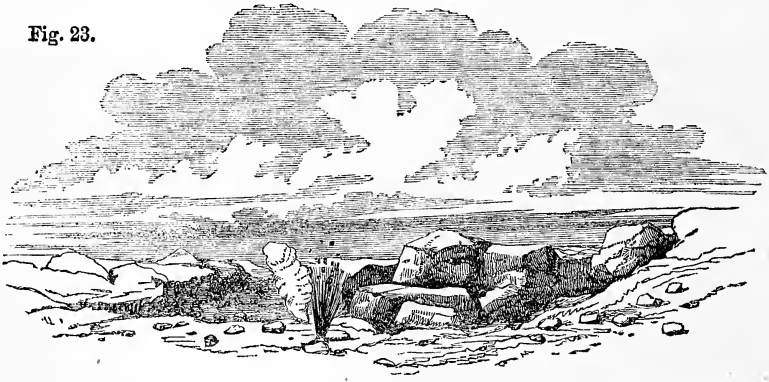
In firing on to ground, either marshy naturally, or soft after rain, the projectile sinks and produces little more effect than a shower of mud. Fig. 22.

Fig. 22.



In firing on to a rocky site, the shells will be canted up, or off, and the result on the target very uncertain; sometimes very destructive, at others just the reverse. Fig. 23.

Fig. 23.



Suppose the targets placed on the side of a hill; in this case the shell

Fig. 24.

will probably penetrate, should the ground be soft, or, as in Fig. 24, suffer deflection should it be rough or stony.

We will take another case, in which shells burst by percussion will do very little if any damage to the target. Suppose an abrupt short descent embankment, side of a cultivated hill, &c., as in Fig. 25, a target placed on the crest would hardly be injured by shells burst by percussion.

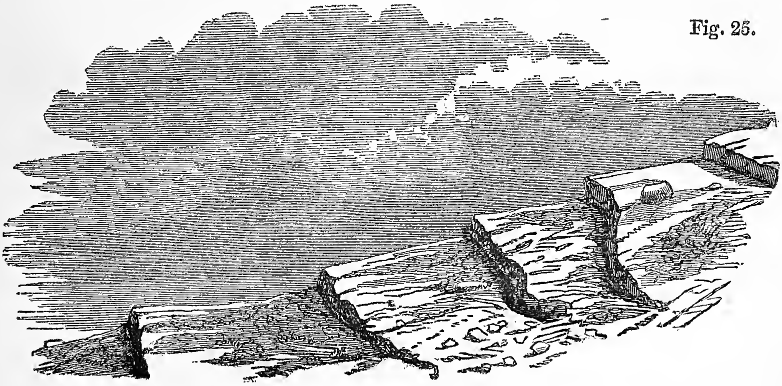


Fig. 25.

And, generally, in any broken ground whatever, or uncleared land, such as is indicated faintly in Fig. 26; attempts to produce good effects, by bursting shells on impact, will probably end in disappointment.

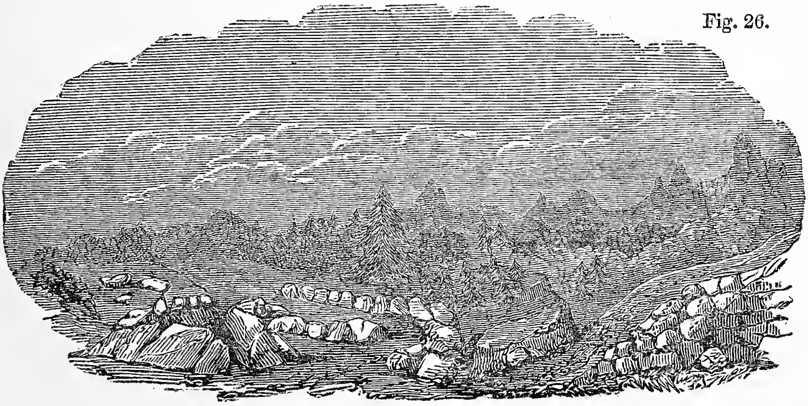
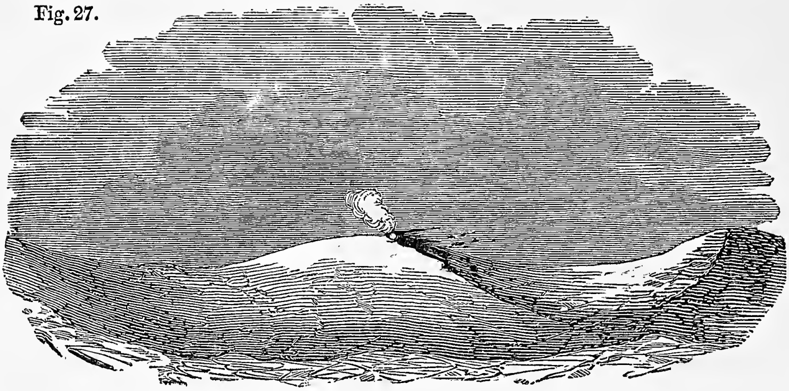


Fig. 26.

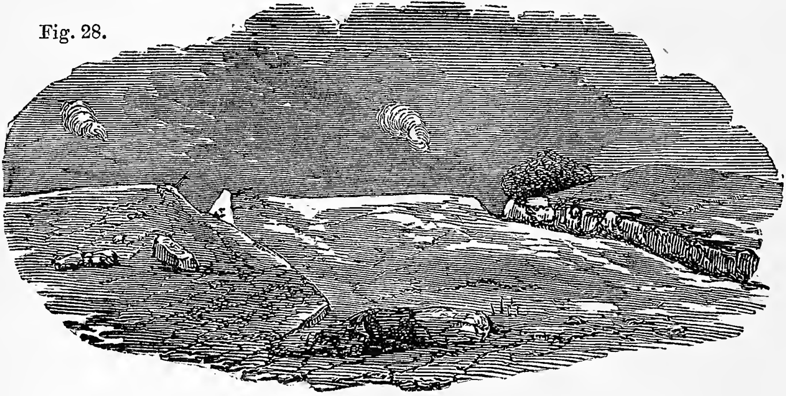
In the case of gently undulating ground, such as is shewn in Fig. 27, and presenting nothing when seen from the front, but a series of ridges very undefined, the enemy posted on the reverse sides, time fuzes must be used, to burst the shells at the crest.

Fig. 27.



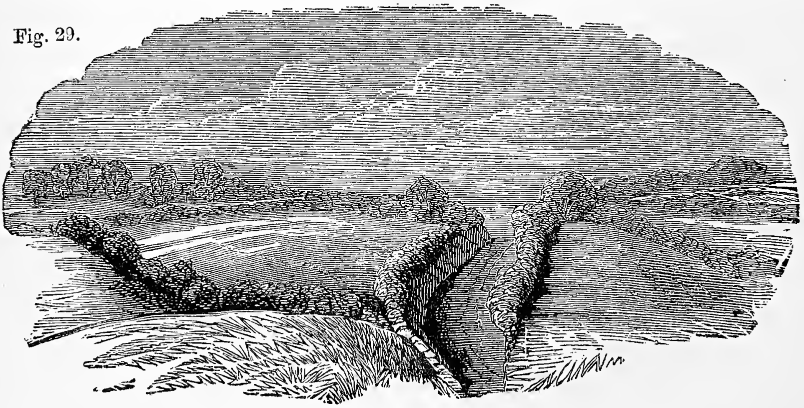
In the same way time fuzes are alone applicable in the case of troops posted in shallow ditches, or behind hedges (Fig. 28), and in these cases howitzer fire is necessary.

Fig. 28.



As regards deep sunken roads (Fig. 29), or positions simply of defence

Fig. 29.



and cover, with no view to offence, then vertical fire must be used, of which we are not now treating.

The effects of firing over earth are not so clearly visible from the gun as in firing over smooth water. In the latter case, a line of foam, or spray is very distinct; in the former, pieces of turf, mud, and earth, are thrown up, few in number and *comparatively* indistinct, until skill is obtained by practice.

And now a few words as to the future. The ascendancy or otherwise of the artillery may depend entirely upon the first few rounds fired. As at the Cape of Good Hope* and elsewhere, an ill directed fire, or well directed but worthless projectiles,† serve only as an encouragement to our opponent. On the other hand, we have experience to shew that, as at Vimiera and in Java, a few projectiles of good construction judiciously employed, will strongly influence, if not decide, the fate of an action.

To this end the first requisites are *good training* and simplicity of construction; (good horses and bold driving need not be insisted upon with British troops), a plain strong tangent scale with two matters *only* legibly engraved thereon, namely *ranges* and *length of fuze* to correspond; slow motion arrangements, and verniers may be kept for 3000 yard ranges. The fuzes should be fixed *at* the gun, and if it is considered necessary to have fuzes ready bored, as was the case during the Peninsula War, then each gun number might carry a small fuze pouch with a fuze corresponding to his number; No. 2 for example having ·2 fuzes, No. 3 having ·3, and so on, independently of the fuzes carried in the ordinary way in the limbers and wagons.

Very briefly then, what will good training yield? Mature judgment—the result of observing the effects of shrapnel, over various forms of ground, under different atmospheric circumstances, and at many features and objects. Instead of habitually setting up a well-defined target, fully exposed to fire, let its existence be at times barely indicated, as if the enemy had availed himself—as he assuredly will do—of every undulation of ground, and natural cover to conceal his operations. We may possibly in this case have to resort to curved fire, which will be very instructive. It may be desirable to accustom the eye to observe certain features such as embrasures, rifle pits, parapets, abattis, pallisades, and so forth; and to accelerate, occasionally, the service of the gun to the utmost, and by rough work to test the temper, skill, and proficiency of the soldier, placing the gun in difficulties, capsizing, mounting, shifting, changing rounds, and never firing twice consecutively at the same target. If this can be combined with throwing up rapid cover for the gun, or embarking and disembarking it, so much the better.

In concluding these remarks, I beg as an old instructor to express my gratification at the judicious recommendation of the O.S. Committee,‡ to introduce immediately the shrapnel shell and Boxer's wood time fuze for all breech-loading guns.

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* Vide Vol. V. p. 398.

† As at St Sebastian. See Vol. V. p. 418.

‡ See "Short Notes on Professional Subjects," 1868, p. 41.

Bearing in mind the nature, object, and application of each projectile used in the field—for close quarters, for distance, and for cover—and how necessary it is that their distinctive qualities should be recognized, the recent recommendation of the O.S. Committee does them infinite credit; and it is not too much to affirm that the nation will be a great gainer thereby.

It only remains to add that my very condensed remarks on training have more reference to the field than to siege or defensive operations. To go fully into these two last, or to attempt to exhaust the subject, would be out of place in these "Proceedings."

ANNUAL REPORT

AND

ABSTRACT OF PROCEEDINGS OF A GENERAL MEETING OF THE ROYAL ARTILLERY INSTITUTION, HELD ON 15th MAY, 1868.

COLONEL ADYE, C.B. IN THE CHAIR.

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1. THE Committee of the Royal Artillery Institution have the honor to present to the Annual General Meeting their Report and Abstract of Accounts for the year ending 31st March, 1868.

It will be seen by the accompanying Table, that during the past year 75 Officers have joined the Institution, and, after allowing for casualties caused by deaths and withdrawals, there is a net increase of 21 members.

RANK.	£	s.	d.	April, 1867.	Additions due to promotion.	New members.	Promoted, withdrawn, and deceased.	April, 1868.
EFFECTIVE LIST.								
General and Regimental Field Officers, paying annually	1	5	0	188	+ 3	+ 6	– 9	188
Captains	0	16	0	428	+20	+22	–20	450
Lieutenants	0	10	0	528	0	+39	–50	517
Paymasters	1	5	0	1	+1	0	– 1	1
do	0	16	0	5	+2	+ 1	0	8
Quarter-Masters	0	10	0	8	0	+ 1	– 1	8
Riding-Masters	0	10	0	6	0	0	– 1	5
Surgeons-Major	1	5	0	7	0	0	– 1	6
Surgeons	0	16	0	1	0	+ 1	0	2
Assistant-Surgeons	0	16	0	23	0	+ 1	– 4	20
Veterinary Surgeons	0	10	0	3	0	0	0	3
RETIRED LIST.								
General and Regimental Field Officers	1	5	0	26	+10	+ 2	0	38
do. do.	0	16	0	1	0	0	0	1
do. do.	0	10	0	8	0	0	– 1	7
do. do.	0	7	6	6	0	0	– 2	4
Captains	1	5	0	1	0	0	0	1
do.	0	16	0	25	0	0	– 7	18
do.	0	10	0	4	+ 3	0	0	7
do.	0	5	0	6	0	0	0	6
Lieutenants	0	10	0	0	+ 4	0	0	4
Surgeons-Major	1	5	0	2	0	0	0	2
Chaplains	1	5	0	1	0	0	0	1
				1278	+43	+73	–97	1297
Honorary Members	0	10	6	37	0	+ 2	0	39

A List of Members accompanies this Report, five years having now elapsed since such a record has been published.

2. With regard to the financial condition of the Institution, the Committee are glad to be able to submit a favourable Balance Sheet. At the date of the last Annual Report, a sum of £200 was due to Messrs Cox & Co., this debt has been paid off, and the D^{r} and C^{r} account shows a balance of £1932. 16s. 4d. in favour of the Institution, being an increase of £185. 2s. 3d. in the year.

The services of the Secretary of the Institution having been temporarily required by the Secretary of State for War in December last, the Committee obtained the sanction of the Deputy-Adjutant General, Royal Artillery, to the appointment of Captain Ford, R.A., as Acting Secretary; and it gives them pleasure to record their opinion of the able manner in which that Officer conducted the business of the Institution during the four months of the past year that he was thus employed.

3. *Printing and Publication.*—Volume V. of the "Proceedings" has been completed. The papers enumerated in the annexed list have been published during the past year, and the Committee express their sincere thanks to those who have thus contributed much valuable information for the Professional Papers.

List of "Proceedings" printed during the year.

On the Geology of Gibraltar, with especial reference to the recently Explored Caves and Bone Breccia. By Lt. Alexander B. Brown, R.A., F.R.A.S., F.G.S.

Shells for Rifled Field Guns. By Lieut. J. T. Barrington, R.A.

The comparative Advantages of Breech-loading and Muzzle-loading systems for Rifled Field Artillery. By Lieut.-Colonel F. Miller, R.A., V.C.

Annual Report and Abstract of Proceedings of a General Meeting of the Royal Artillery Institution, held on Monday, May 6, 1867. Brigadier-General J. H. Lefroy, R.A., F.R.S., in the Chair.

A Lecture on the Campaigns of 1866 in Germany. By Lieut.-Colonel F. Miller, R.A., V.C.

The Shrapnel of the Past. By Major-General W. B. Gardner, R.A.

Boxer's wood Time Fuze for M.L. ordnance (Rifle and Smooth-bored). By Captain Vivian Dering Majendie, R.A., Assistant Superintendent, Royal Laboratory.

The Siege of Madras. By Sidney Owen, M.A., Lee's Reader in Law and History at Christ Church; and Reader in Indian Law in the University of Oxford.

Tactical and General Instructions for the I. R. Northern Army, issued in May, 1866, by the Feldzeugmeister Chevalier von Benedek. By Major Goodenough, R.A. (Translated from the Oestreichische Militarische Zeitschrift of September, 1866).

Mountain Train formed for Service in Abyssinia. By Capt. C. O. Browne, R.A., Captain Instructor, Royal Laboratory.

Translation of a Royal Decree passed recently in the Italian Parliament. By Captain Maynard Wolfe, R.A.

On a Clinometer for Elevated Coast Batteries. By Capt. J. R. Oliver, R.A.

Extracts from Report on Ballistic Experiments carried on during the years 1861-2, under the Direction of the O.S. Committee. By Captain W. H. Noble, M.A., R.A., Associate Member, O.S. Committee.

Short Notes on Professional Subjects, 1868. Nos. 2—6, pp. 5 to 44.

General Abstract of the Income and Expenditure of the Royal Artillery Institution, from 1st April 1867, to 31st March 1868.

	EXPENDITURE.	£	s.	d.
	Paid Messrs Cox and Co. sum advanced	200	0	0
Printing and Publication	Wages	225	1	8½
	Paper, £254.14s. Type&Materials, £203.6s.5½d.	458	0	5½
	Wood Cuts, £48. 11s. Lithography, £77. 1s. 3d,	125	12	3
Photography	Chemicals and Apparatus	29	1	4
	Printing, Mounting, &c.	236	5	2
	Drawing	82	9	2
	Lectures	30	2	10
	Taxidermy	7	7	0
	Library, Books, &c.	191	7	1
	Museum	56	0	3
	Instruments	2	15	6
	Carpenter's Wages, £19. 17s. 3d. Materials, £53. 10s. 4½d.	73	7	7½
	Insurance on £5000, to 24th June, 1868	16	5	0
	Furniture and Repairs	5	3	6
	Subscriptions to Societies	2	2	0
	Stationery	331	3	7
	Postage and Parcels	54	18	2
	Wages, Clerks and Orderlies	132	2	7
	Incidental	54	13	1½
	War Office Photographs	20	19	6
Cash in hand, 31st March, 1868,	Secretary 2 15 6 Messrs Cox & Co. 58 7 11	61	3	5
		£ 2396	1	3

	INCOME.	£	s.	d.
	Cash in hand, 1st April, 1867	5	17	1
	Dividend on £1200 Consols (to 5th Jan. 1868)	35	5	0
Subscriptions, to 31st March, 1868	Annual	983	3	6
	Entrance	73	0	0
	Paid in Advance	6	5	0
	General Printing	447	7	10
Photography	Chemicals and Apparatus	4	14	4
	Printing, Mounting, &c.	268	6	5
	Drawing	65	2	1
	Taxidermy	9	9	2
	Classes (Italian, &c.)	3	10	5
	Library, Books, &c.	114	8	6
	Carpenter, Wood, &c.	21	15	3
	Stationery	257	14	11
	Postage and Parcels	22	17	0
	War Office Photographs	77	4	9
		£ 2396	1	3

DEBTOR AND CREDITOR ACCOUNT, 31st MARCH, 1868.

		£	s.	d.
Outstanding Debts, 31st March, 1868	Printing Material	95	16	4
	Stationery	83	16	4
	Drawing Instruction	25	4	0
	Library Binding	10	0	0
	Due to W.O. for Photographs and Lithographs	98	5	3
	do for Subscriptions to Societies	3	3	0
	Balance Creditor	1932	16	4
		£ 2249	1	3

		£	s.	d.
Balance Creditor	Consols Stock	1200	0	0
	Cash in hand, 31st March, 1868	61	3	5
Approximate value of	Books and Stationery, for Sale.	120	0	0
	Printing Paper, on Stock, and Printed Matter	160	0	0
	"Handbooks" do.	196	13	4
	Chemicals (Laboratory) £20, (Photographical) £20 =	40	0	0
Amount owing by Officers and others.	Books, &c.	44	2	9
	"Handbooks"	186	17	8
	Drawing	9	4	8
	Photography	49	15	1
	Postage	14	18	2
	Printing	33	16	1
	Stationery	53	7	2
	Wood	1	8	11
	W.O. Photographs and Lithographs	43	17	0
	Amount owing for back Subscriptions	33	17	0
		£ 2249	1	3

WOOLWICH,
8th April, 1868.

A. HARRISON, Captn., R.A.. Secy. R.A.I., & Treasurer.

Much interesting information has been published in the "Short Notes on Professional Subjects," which have accompanied each issue of the "Proceedings" since the last Report. Whilst thanking the contributors of the 50 pages already issued, the Committee hope for the co-operation of a larger number of Members in support of this means of imparting to their brother officers, the observations and experience of individual members on subjects of Professional and Scientific interest.

A revised copy of "List of Service Guns and Ammunition" corrected to March 31, has been issued to the Regiment, and it is gratifying to know that this publication has proved eminently useful.

Some Members having expressed a wish for an Alphabetical List of the officers of the Regiment serving on full pay, showing dates of first and present commission, similar to one compiled by Lieut.-Colonel (then Major) Miller, R.A., in 1860, it was decided to publish the required information in a handy form for sale to Members at cost price. The first number was issued in November, and the list will in future be published quarterly. The cost to subscribers is one shilling a year exclusive of postage, or single numbers can be obtained by Members, price 6d. each.

The Committee have pleasure in informing the Meeting that 200 officers have entered their names as subscribers to the new edition of Kane's list. The present edition has been revised and corrected under the superintendence of Lt.-Col. Miller, R.A., and as the printing will be immediately commenced, it is hoped that subscribers will have received a copy of Part I. (the List of Officers of the old Royal Artillery), before the next Annual Meeting. When sufficient subscribers are obtained, it is intended to publish Part II. as notified to Members in Circular No. 25. This Part will contain information in the same form as that published in Part I., but relating to the late Indian Brigades.

4. *Library.*—A second-hand copy of Paxton's Magazine of Botany (16 vols.) having been offered to the Institution for a very reasonable sum (£6) the Committee, finding the volumes complete and in good order, were glad to secure so valuable a work for the Library, especially as the R.A. Institution was deficient of any standard book in this department of science. The library has since been enriched by a copy of Paxton's Flower Garden (3 vols.), and the Committee have to thank Lt.-Col. Gosling, R.A., for this handsome gift.

The Committee also gratefully acknowledge the presentation by the Author, Mr John Stuart, of a very interesting volume on the Sculptured Stones of Scotland. Mr Stuart hopes that the attention of Officers of Artillery, especially those likely to serve in India, may thus be drawn to the interest attaching to a class of symbols which may be of Indian origin, and to induce them to take note of even the rudest markings which have any appearance of antiquity, in caves, on rocks, &c.

The list of changes in Artillery *matériel* can now be procured by Members gratis on application to the Secretary of the R.A. Institution, the Secretary of State for War having informed the Committee that he will have much pleasure in supplying these lists gratuitously in future.

There has been a sale of 544 War Office Photographs and 2500 Lithographs during the past year, and lists of those published since the last Report are sent to Members.

The following books, plans, &c. have been purchased and presented, since the last Annual Meeting.

Books, &c. presented.

Proposed Regulations for Horse Artillery in India	...	Lieut. A. W. O. Whinyates, R.A.
R. G. F. Lithographs	4	The Secretary of State for War.
R. C. D. Lithographs	10	
Royal Laboratory Lithographs	27	
W.O. Photographs	280	
O.S. Committee Extracts, Part 4, Vol. IV. and Parts 1, 2, & 3, Vol. V. (6 of each)	...	
Second Annual Report of the President of the Ordnance Select Committee, 1865-6	3	
Addenda and Corrigenda to War Office Catalogue	1	
Report of a Committee appointed to enquire into the administration of the Transport and Supply Department of the Army	1	
Parliamentary Papers, Session 1866-7	...	
Collection of views in Abyssinia	...	
Nomenclature of the component and loose parts of wrought-iron Carriages for M.L.R. Guns	1	
Sitana, by Col. J. M. Adye, C.B.	1	The Author.
Index to Periodical Publications received in W.O. Library, Apr. 1867, to Mar. 1868	...	The Librarian, War Office.
Les Institutions Militaires de la France	1	Captain H. Brackenbury, R.A.
L'Armée Française en 1867	1	
Astronomical and Meteorological Observations taken at Washington, during the year 1864	1	The Superintendent, U.S. Naval Observatory, Washington.
Catalogue of Books added to the R.A. Library from 1st January 1865 to 31st March 1867	1	The Committee, R.A. Library.
Steel Engraving of Robert Devereux, Earl of Essex	1	Capt. W. R. Llwellyn, R.A.
Domestic Architecture of the Middle Ages, 2 Vols.	...	J. Hewitt, Esq.
Hallam's Middle Ages, 3 Vols.	...	
Mémoires sur l'Ancienne Chevalerie, 3 Vols.	...	
Ancient Egyptians, 2 Vols.	...	
Photographs of Kaffirs	4	Lieut. Col. H. Chermside, R.A.
Photograph of Floating Dock	1	Lieut. E. H. Wickham, R.A.
Artistic Anatomy of the Horse, by B. Waterhouse Hawkins	1	The Author.
Pamphlet on the Hand Mortar of the beginning of the 17th century, in the R.A. Museum, by J. Hewitt	...	The Author.
Photographs of Prussian Field Artillery	2	Col. W. B. Gardner, R.A.

Memorandum on the Prussian Campaign of 1866, by Lt.-Col. Reilly, C.B., R.H.A.	4	Director of Ordnance.
Statement of the Relative Pecuniary Position of the Soldier, and Agricultural and Town Labourer..............	2	
Treatise on Ammunition, Part I............	3	
12 Copies "Notes on Matériel," &c. by Capt. E. A. Slessor, R.A.	...	
View of Magdala, Abyssinia	2	
A few Stray Thoughts upon Shakespeare, by T. Howell	...	The Author.
Observations on Lt.-Col. Reilly's Memo, by Rear Admiral J. C. Caffin, C.B., R.N....	15	The Author.
Hart's Quarterly Army List for January, April, July, and October 1867	...	R.A. Library, Woolwich.
Lecture on the Stability of Gun Cotton, by F. A. Abel, Esq.	...	The Author.
Tour of Artillery Officers in Russia, 1866	...	The Deputy Adjutant General, Royal Artillery.
Journal of the Royal United Service Institution, Nos. 42-46	...	The Council, Royal United Service Institution.
W.O. Army List, 1867-8	...	Messrs Cox & Co.
Journal of the Royal Geographical Society, Vol. XXXVI.	...	The Council, Royal Geographical Society.
Proceedings of the Royal Geographical Society, Nos. 2-5, Vol. VI.		
Proceedings of the Zoological Society of London, Parts, 1, 2, 3, 1866, 1, 2, 1867	...	The Council, Zoological Society of London.
Memoir of Col. J. Nisbett Colquhoun, R.A.	3	The Council, Institution of Civil Engineers.
„ Capt. W. F. L. Carnegie, R.A.	3	
Photographic Views of St Helena	2	J. J. Lilley, Esq.
Map of the City and entire Suburbs of Canton	...	Capt. G. A. Crawford, R.A.
Mémorial de l'Artillerie de la Marine, Part 2, 1866, Part 1, 1867	...	French Government, through Captain C. Pigeard, Naval Attache.
The Electric Telegraph: was it invented by Professor Wheatsone?	3	Lieut.-Col. W. G. Andrewes, R.A.
Washington Astronomical Observations, 1851-2	...	The Superintendent, U.S. Naval Observatory.
Smithsonian Miscellaneous Collections, Vols. VI. & VII.	2	Smithsonian Institution.
Smithsonian Report, 1865		
Annual Report of the Secretary for War, 1866	...	The Secretary for War, United States.
Photo-Zincograph and Letter Press translation of Magna-Charta	...	The Director, Ordnance Survey, Southampton.
Examination Papers, R.M.A., June 1867, and December 1867	...	Inspector of Studies, R.M. Academy.
Routes in Abyssinia	2	The Director, Typographical Department, War Department.
The Army of Great Britian, 1867-8	2	
Route Map of Abyssinia	2	
Lecture on Drainage, Sewage, Irrigation, Water Supply, and Water Works	...	The Director, R.E. Establishment, Chatham.

Monthly Notices of the Royal Astronomical Society	...	The Council, Royal Astronomical Society.
Photographic Views of Patent Floating Dry Dock for Bermuda	...	Capt. J. L. Clarke, R.A.
Lecture on the Penetration of Armour Plates by Steel Shot, &c., by Captain W. H. Noble, R.A.	...	The Director, R.E. Establishment, Chatham.
Sulle Traiettorie Identiche e sui Proietti Equipollenti, di Antonio Araldi	...	The Author.
Photographic Portraits of Lord Raglan, Omar Pacha, and General Pellissier	...	Lieut.-Col. H. Chermside, R.A.
European Armaments in 1867, by Captain C. B. Brackenbury, R.A.	...	The Author.
Prussian Handbook for Artillery Officers...	...	Lieut. A. Rawlins, R.A.
Original Photograph, shewing the order of anchoring of the British Transports on the landing in the Crimea	...	Lieut.-Col. H. Chermside, R.A.
Kaffir Laws and Customs		
Panoramic View of Charles Town, South Carolina	1	Maj.-Gen. A. Tulloh, C.B., R.A.
Views of Gibraltar	3	
View of the Siege of Louisborough	1	
H.M.S. "Swan" and "Sulphur" with a Convoy from New York for England forcing through the ice, 1790	1	
A view of the Flying Proa in the Ladrone Islands	1	
Minutes of Proceedings of the Institution of Civil Engineers, Vol. XXVI.	...	Institution of Civil Engineers.
Biblica Hebraica, 1662	...	C. E. Grieness, Esq.
The Eastern Traveller's Interpreter		
Palæstra Linguarium Orientalium		
Panoramic View of the Bosphorus	...	Lieut.-Col. W. C. F. Gosling, R.A.
Paxton's Flower Garden, Vols. I., II., III.	3	
Photographic Copy of Picture, "The Day after the Cyclone at Calcutta, 6th Oct. 1864"	...	Major W. A. Ross, R.A.
Description of Two Routes through Nicaragua, by Lieut. S. P. Oliver, R.A. F.R.G.S.	...	The Author.
Russian Artillery Journal, 1 to 9, 1867	...	Col. N. de Novitzky, Russian Embassy.
″ Small Arms, ″ 1 to 4, 1867		
″ Engineers ″ 1, 2, 3, 1867		
″ Military ″ 4 Parts, 1867		
″ Pamphlet		
The Safes' Challenge Contest at the Paris Exhibition, 1867	...	R. Mallet, Esq. C.E., F.R.S.
Photographic Views of Malta	2	Lieut. J. Speranza, Royal Malta Fencible Artillery.
Map of Prince of Wales Island, or Pulo Penang, and Province Wellesley	...	Lieut.-Col. A. E. H. Anson, R.A.
Lectures on the Properties and Characteristics of different kinds of Timber	...	Director R.E. Establishment, Chatham.

Notes on Cast-iron and Bronze Ordnance, for the use of Inspectors of Warlike Stores, &c.	The Director of Ordnance.
Authorship of the Practical Electric Telegraph, by the Rev. T. Fothergill Cooke, M.A.	Lt.-Col. W. G. Andrewes, R.A.
Rumoured Reconstruction of the Royal Artillery, by a Brevet Lieut.-Col., R.A.	The Author.
Professional Papers of the Corps of Royal Engineers, Vol. XV.	The Editor.
Notes on the History, Methods, and Technological Importance of Descriptive Geometry, by A. W. Cunningham.	The Author.
Commitment of Mooghul, the murderer of Mr Simon Frazer, Captain Douglas, Miss Jennings, Miss Clifford, and others, at Delhi, 11th May, 1857, being the commencement of the Mutiny, and summary of the case in the handwriting of the judge	Capt. W. A. Ross, R.A.
Manuscript letter from Lieut. Howard Douglas, R.A., to Captain Augustus Fraser, R.A., detailing account of the Shipwreck of the Transport "Phillis," 1795	Brig.-General J. H. Lefroy, R.A., F.R.S.

Books purchased.

Correlation and Continuity, by Grove. One Vol.
Our Tropical Possessions in Malayan India. One Vol.
The Ibis. Nos. 10, 11, 12, and 13. Vol. III.
Familiar Lectures on Scientific Subjects, by Sir John Herschel. One Vol.
Gould's Birds of Asia. Part XIX.
Kars, and our Captivity in Russia, by Colonel A. Lake, C.B. One Vol.
Correspondence of General Sir J. Cathcart. One Vol.
L'Armée Francaise en 1867. One Vol.
Études sur l'organisation des Armées et particulièrement de l'armée Belge. One Vol.
Un mot sur le projet de réorganisation Militaire, par le Général Changarnier. One Vol.
Paxton's Magazine of Botany. 16 Vols.
Bacon's Theory of Colouring. One Vol.
Gould's Birds of Great Britain. Parts XI. XII.
Parochial and Family History of the Parish of Blisland, in the County of Cornwall. One Vol.
Revue de Technologie et d'art Militaires. Vol. VI.

List of Periodical Publications.

Journal de Mathématiques.
Journal des Armes Spéciales.
Comptes Rendus.
Crelle's Journal.
Le Spectateur Militaire.
Philosophical Magazine.

Journal of the Society of Arts.
British Journal of Photography.
The Photograpic News.
Jackson's Woolwich Journal.
The Times.
Engineering.
Proceedings of the Meteorological Society.
Publication of Palæontographical Society.

Arundel Society Plates.

Zaccharias naming his son John.
Preaching of John the Baptist.
Poetry.
The Ecstasy of St Catharine.
The Martydom of St Stephen.

5. *Museum.*—A list of the various donations to the Museum accompanies this report. The large collection of birds from Malacca, presented by Captain McMahon, R.A. and Lt. Roberts, R.A., comprising 147 specimens, is a very valuable addition, as also the fine collection of reptiles from the same locality, presented by Lieut. Souper, R.A.; a series of Coleoptera from Southern Europe, received from Colonel Williams, R.A., C.B., contains some rare kinds. The specimens of coral from Bermuda presented by Lieut. Griffin, R.A. are worthy of notice. Four glass cases, to contain some of the handsome birds recently received, have been added during the year.

In conchology presentations have been made from abroad by Lieut. W. Warren, R.A., and Lieut. Hime, R.A., and by W. Rawes, Esq. of British specimens.

The collection of minerals kindly presented by Rear-Admiral Goldsmith, C.B., contains some fine specimens of stalactite and stalagmite.

Presentations to Museum.

Birds from South Australia	5	Capt W. H. Graham, R.A.
Marsh Harrier	1	Asst.-Surg. J. M. Fiddes, M.D., R.A.
Japanese case shot	2	Lieut. A. F. Gardner, R.N.
" matchlock pistol	1	
Blanket and Dress, manufactured by the natives of Nicaragua and Guatemala (4 pieces)	...	Lieut. S. P. Oliver, R.A.
Birds	5	Lieut. T. Griffin, R.A.
Gergonius	2	
Shingo	1	
Shells	4	
Sea Egg	1	
Piece of Gulf Weed	1	
Collection of shells	...	
Bottles of reptiles, insects, &c.	15	Lieut. C. E. Souper, R.A.
Argus Pheasant (male and female)	2	
Model of Chinese coffin	1	
Box carved by Chinese from bamboo	1	
Chinese pellet bow	1	
Piece of "Man Trap" from Singapore	1	
Japanese fishing rod	1	

Trays of insects	2	Lieut. W. A. Warren, R.A.
Piece of petrified gum-tree	1	
Pieces of Coral	3	
Specimen of Marine Animal	1	
Pairs of Large Shells	3	
Boxes of Small Shells	2	
Specimen of Remorœ (in spirits)	...	Major W. A. Ross, R.A.
Sabre, presented by Col. Congreve to Serjt.-Major Walker, R.A., for his services in Flanders	...	Qr.-Master T. Gibson, R.A.
Specimen of Sparrow Hawk	...	Lieut. O. F. T. Annesley, R.A.
Birds from Malacca	47	Capt. C. J. McMahon, R.A.
" "	100	Lieut. H. Roberts, R.A.
Birds' Skins	8	Lieut.-Col. P. W. L'Estrange, R.A.
Deers' Heads	2	
Specimens of auriforous quartz from Ballarat	4	Capt. C. J. McMahon, R.A.
Specimen of quartz from Tasmania	2	
Apatite from Upper Canada	...	Lieut. C. Jones, R.A.
Collection of British Fish...	...	W. W. Rawes, Esq.
" Insects from India		
" Minerals, Stalactites, &c....	...	Admiral Goldsmith, C.B., R.N.
Pair of Sandals from Cashmere	...	Major W. A. Ross, R.A.
Specimen of Tincal or Native Borax, from Tibet		
Collection of British Birds' Eggs	...	Lieut. R. Gamble, R.A.
" Indian Butterflies	...	Capt. E. H. Thurlow, R.A.
Model of a 9-pr. Indian Gun and Carriage complete	...	Lieut. J. R. Wilmer, R.A.
Collection of Shells from Ceylon	...	Lieut. H. W. L. Hime, R.A.
Model of the Cawnpore Monument	...	Capt. W. A. P. Wyllie, R.A.
North American Bow and Arrows	...	Maj.-Gen. R. Burn, R.A.
Lace-bark Whip, Supple Jack, and Sea Rod, from West Indies	...	Asst.-Surg. J. Wales, R.A.
Collection of Pholas and British Land Shells	...	W. Rawes, Esq.
Collection of Coleoptera from Mediterranean	...	Col. E. A. Williams, C.B., R.A.
Indian Matchlock Barrel, handsomely inlaid, from Jhansi	...	Maj.-General C. Lucas, R.A.
Tail of Fish from the River Indus		
2 Specimens of Iron Pyrites from the Camp at Chalons	...	Officers of the Foreign Tour in 1867.
Specimens of Middle and Shore ends of Atlantic Telegraph Cable	...	F. Le Breton, Esq.
Specimen of "Wash Dirt" from the Koh-i-noor mine, Ballarat, Victoria ...	...	Capt, C. J. McMahon, R.A.

Presented by Lieut. Griffin, R.A., Birds, &c. from Bermuda.

Buteo borealis.
Sialia sialis.
Mimus carolinensis.
Phaeton flavirostris.
Gergonias.
Fine specimen of sponge.
A few shells.

Presented by Captain Graham, R.A., Birds from Australia.

Palæornis barrabandi.
Nanodes undulatus.
Nymphicus novæ Hollandia.

Presented by Lieut. C. E. Souper, R.A., Birds and Reptiles from Malacca and Singapore.

Argus giganteus ♂ ♀
Reptiles in spirits.

Presented by Lieut. W. A. Warren, R.A., from India, &c.

Two boxes lepidoptera.
Coral, and shells.

Presented by Captain McMahon, R.A., Birds from Malacca, amongst which are the following species.

Dacelo pulchella ♂ ♀
Harpactes diardi ♂ ♀
Eurylaimus ochromalus ♂ ♀
Nyctiornis amictus.
Cymbirhynchus macrorhynchus.
Corydon sumatranus ♂ ♀
Irena puella ♂ ♀
Megalaima hayi ♂ ♀
Megalaima viridis.
" philippensis.
Calyptomena viridis ♀
Ierax cærulesceus ♂ ♀
Vanga cristata.
Phyllornis javensis ♂ ♀
Copsychus saularis.
Picus mentalis.
Bucco versicalor.

Presented by Lieut. H. Roberts, R.A., Birds from Malacca, amongst which are the following species.

Harpactes duvanceli ♂ ♀
" dairdi ♂ ♀
Phyllornis javensis ♂ ♀
Merops philippinus.
Corydon sumatranus ♂ ♀
Eurylaimus ochromalus ♂ ♀
" javanicus ♂ ♀
Cymbirhynchus macrorhynchus.
Copsychus saularis.
Pitta cyanoptera.
Picus mentalis.
" puniceus.
Vanga cristata.
Bucco versicalor.
Alcedo bengalensis.
Dacelo pulchella ♂ ♀
Nyctiornis amictus.
Irena puella ♂ ♀
Megalaima hayi ♂ ♀
" philippensis.
Calyptomena viridis ♀
Ierax cærulescens ♂ ♀
Columba jumboo.
Tringoides hypoleucos.

Presented by Lieut. O. F. T. Annesley, R.A.

Accipiter nisus ♀
Sparrow Hawk.

Presented by Lieut. K. Gamble, R.A., Eggs of British Birds.

Tinnunculus alaudarius.
Accipiter nisus.
Syrnium aluco.
Hirundo rustica.
Troglodytes parvulus.
Calamodyta phragmitis.
Sylvia cinerea.
Phyllopneuste trochilus.
〃 sibilatrix.
Regulus cristatus.
Pratincola rubetra.
〃 rubicola.
Erythacus rubecula.
Parus cæruleus.
〃 caudatus.
Motacilla yarrellii.
Hydrobata cinclus.
Turdus viscivorus.
〃 musicus.
〃 merula.
Pica caudata.
Corvus frugilegus.
Corvus monedula.
〃 corone.
Fringilla cælebs.
Chlorospiza chloris.
Linota cannabina.
Passer domesticus.
Emberiza schœniclus.
〃 citrinella.
Alauda arvensis.
Perdix cinerea.
Phasianus colchicus.
Lagopus scoticus.
Vanellus cristatus.
Charadrius hiaticula.
Gallinago media.
Rallus aquaticus.
Ortygometra crex.
Gallinula chloropus.
Fulica atra.
Hœmatophus astralegus.
Anas boschas.
Podiceps minor.

Presented by Captain E. H. Thurlow, R.A.

Small collection of Indian lepidoptera.

Presented by Lieut. H. W. L. Hime, R.A.

Shells from Ceylon, amongst which are some interesting species.

Presented by W. Rawes, Esq.

A very interesting collection of British land and marine shells, amongst which are some fine specimens of Pholas.

Presented by Lieut.-Colonel L'Estrange, R.A.

Argus giganteus.
Platalea leucorodia.
Diomedea chlorohynchus.
Pelecanus aquilus.
Sula fuscus.

Presented by Col. Williams, R.A., C.B., Coleoptera from Southern Europe, amongst which are the following species.

Cicindela campestris.
Carabus auratus.
〃 clathratus.
Calosoma sycophanta.
Melolontha fullo.
Cetonia aurata.

Presented by Lieut. S. Parry, R.A., insects from Gibraltar, amongst which are the following species.

Papilio machaon.
Gonepteryx rhamni.
〃 cleopatra.
Colias edusa.
〃 hyale.
Pontia brassicœ.
Vanessa atalanta.
Cynthia cardui.
Hipparchia megœra.
〃 janira.
Saturnia pavonia-major.
Arctia villica.

Museum Purchases.

Specimen of Enchodus Halocyon, belonging to the Mackerel tribe, from Charlton Pit.

Fourteen Flint Implements, from a collection made in Yorkshire; Ancient British Arrow-heads and Spear-heads, selected from the thirty years' gathering of Mr Tindall.

List of Service Projectiles, &c., presented to the Institution by H.M. Government.

Cartridge for Snider converted Enfield Rifle, complete and in section.
Boxer's 10 seconds Wood Time Fuze for M.L. 7-pr. complete.

6. *Taxidermy.*—Thirteen Officers have received instruction in Taxidermy, since the last Annual Meeting. Some Members of the Class have also acquired knowledge in collecting Natural History specimens, a portion of the time in each week during the Summer months having been devoted by Mr Whitely to this useful and instructive study.

7. *Classes.*—The classes for French, German, and Drawing have met regularly, except during a few weeks, whilst the building was in the hands of the Barrack Department for the Septennial cleaning. They have all been well attended during the past year.

8. *Surveying and Practical Astronomy.*—Major Drayson has attended twice in each week to give instruction in these subjects.

The Observatory is in working order, and the telescope has been frequently used during the past year. The Chronometer is in good order, and can be used with the Transit, or Altitude and Azimuth Instrument.

During the coming fine weather there will be many opportunities offered to those who care to study the Moon, Planets, Nebulæ, &c. Due notice is given when suitable evenings for using the large telescope are likely to occur.

9. *Photography.*—Several officers have taken advantage of the excellent Photographic Department of the Institution, and have received instruction in Photography. This Department continues to prosper: during the past year 850 negatives have been taken, from which 9000 copies have been printed.

10. *Lectures.*—The Lectures enumerated in the following list, have been delivered in the Theatre of the Institution to Members and their friends during the past winter, and they have been very largely attended. Thanks are due to Mr Bloxam, Mr Brandram, Mr Hall, Mr Newton, and Mr Warington Smyth, for gratuitous service rendered in this matter.

Rev. A. J. D. D'Orsay, B.D.	The Curiosities of the English Language.
C. K. Salaman, Esq.	Musical Lecture on "The German Opera."
C. T. Newton, Esq., M.A.	Public Games of the Ancients.
S. Brandram, Esq.	Readings from Dickens, &c.
S. C. Hall, Fsq., F.S.A.	"Memoirs, from personal acquaintance of the most Celebrated Men and Women of the Age."
J. H, Pepper, Esq., F.C.S.	"Spectrum Analysis, as applied to Terrestrial Matter, the Planets, Stars, Nebulæ, Comets, and Meteors.
C. L. Bloxam, Esq., F.C.S.	"Certain Chemical Methods of Accumulating Forces."
Warington Smyth, Esq., F.R.S. ...	"Volcanoes."

In consequence of the number of changes which have taken place on the Committee during the year, a modified application of Rule V. is recommended by which the following officers retire from the Committee and are not eligible for re-election:—

Colonel Younghusband,
Captain Arbuckle, Lieut. Sladen, Lieut. Walkey.

The following Members have also left the Garrison, and the vacancies thus occasioned have been filled up by the Committee, subject to the approval of the General Meeting:—

Colonel Wodehouse, C.B.	by	Lieut.-Col. Chermside.
Colonel Cox.	"	Lieut.-Col. Gosling.
Lieut.-Colonel Gosling.	"	Lieut.-Col. Couchman.
Captain Traill.	"	Captain Hobart.
Lieut. Marshall.	"	Lieut. Annesley.

The following resolutions were passed:—

1. *Proposed by Colonel Adye, C.B., seconded by Lieut.-Colonel G. T. Field, and carried,*—

"That the Report of the Committee be adopted and printed."

2. *Proposed by the Committee, seconded by Captain Farmer, and carried, that the following addition be made to* No. V* *of the Rules,*—

In line 2 after "Commandant of the Garrison," *insert* "The Director of Ordnance."

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* The Commander-in-Chief to be Patron and President of the Institution. The Commandant of the Garrison and the Deputy Adjutant-General to be Vice-Presidents, &c.

3. *A vote of thanks was passed to the Secretary and the Chairman, and also to Captain Ford.*

The following Officers were elected to serve on the Committee:—

Lieut.-Colonel Field, Captain Lowry, Lieut. A. B. Brown, F.R.A.S., F.G.S., Lieut. Hime.

The Committee for the current year will stand thus:

PATRON AND PRESIDENT:

Field Marshal H.R.H. the Duke of Cambridge, KG. KP., GCB., GCMG., *fm.*

VICE PRESIDENTS:

The Commandant.
Director of Ordnance.
The Deputy-Adjutant General.

MEMBERS:

The President Ordnance Select Committee.
The Assistant-Adjutant General.
The Secretary Ordnance Select Committee.
The Brigade Major.
The Director of Artillery Studies.

Colonel J. M. Adye, C.B.
Lieut.-Colonel G. T. Field.
" H. L. Chermside.
" E. H. Couchman.
Surg.-Major M. Combe, M.D.
Lieut.-Colonel F. Miller, VC
Captain F. A. Whinyates.
" C. O. Browne.

Captain C. E. S. Scott.
" J. C. J. Lowry
" W. H. Noble.
" G. B. B. Hobart.
Lieut. A. B. Brown.
" H. W. L. Hime.
" O. F. T. Annesley.

Captain T. A. J. Harrison, *Secy. and Treasurer.*

(Signed) J. M. ADYE Colonel,

May 15, 1868. In the Chair.

LIST OF MEMBERS

OF THE

ROYAL ARTILLERY INSTITUTION, WOOLWICH.

[ARRANGED ALPHABETICALLY.]

APRIL 1868.

COLONEL.

FIELD MARSHAL H.R.H. THE DUKE OF CAMBRIDGE, KG., KP., GCB., GCMG., *fm.*
Patron and President.

COLS. COMMANDANT.

Bell, Sir W. 𝔚 KCB., *lg*
Bloomfield, Sir J. 𝔚 KCB., *lg*
Chesney, F. R., *g*
Colebrooke, Sir W. M. G., CB., KH., *g*
Cuppage, Burke 𝔚 *g*
Dacres, Sir R. J., KCB., *g*
England, P. V., *lg*
Griffith, J. G., *g*
Higgins, T. Gordon, *lg*
Ingilby, Sir W. B. 𝔚 KCB., *lg*
Mercer, Alex. C. 𝔚 *g*
Ross, Sir Hew D. 𝔚 GCB., *fm* (*Trustee*)
Sabine, E., *lg*
Scott, Henry A., *g*
Warde, F. 𝔚 *lg*
Williams, Sir W. F. Bt., KCB., *lg*
Wylde, William, CB., *g*

GENERAL OFFICERS.

Abbott, James, *mg*
Anstruther, P., *mg*
Arbuckle, B. H. V., *lg*
Askwith, Wm. H., *mg*
Aylmer, Henry, *mg*
Belson, G. J., *lg*
Blachley, H., *lg*
Black, B. W., *mg*
Brind, J., CB., *mg*
Burn, Robert, *mg*
Burnaby, R., *mg*
Burrows, A. G., *mg*
Christie, H. P., *mg*
Cockburn, C. V., *mg*
Crawford, R. F., *mg*
Dalton, C., *mg*
Dennis, J. B., *mg*
Dick, Francis, *mg*
Dickson, C., CB., 𝔙ℭ *mg*
Dunlop, F., CB., *mg*
Fitzmayer, J. W., CB., *mg*
Flude, Thomas P., *mg*
Freer, J. H., *mg*
Gardner, Wm. B., *mg*
Graydon, G., *mg*
Hanwell, J., *mg*
Huyshe, A., *mg*
Irving, A., CB., *mg*
Lucas, C., *mg*
McCoy, John, *mg*
Ormsby, J. W., *mg*
Paynter, D. W., CB., *mg*
Pester, Henry, *lg*
Riddell, C. J. B., CB., *mg*
Romer, R. F., *lg*
St George, J., CB., *mg* (*Trustee*)
Stow, H., *mg*
Taylor, A. J., *mg* (*Trustee*)
Teesdale, Henry G., *mg*
Thorndike, Daniel, *mg*
Tuite, H. M., *mg*
Tulloh, Alexander, CB., *mg*
Turner, Frank, CB., *mg*
Turner, H. A., *mg*
Warde, E. C., CB., *mg*, *VP.*
Willis, Browne, *lg*
Wingfield, C. W., *mg*
Wood, Sir D. E., KCB., *mg*

COLONELS.

Adair, A. Shafto
Adye, John M., CB.
Barrow, J. L.
Benn, Anthony
Blair, W. H. Stopford
Blunt, C. H., CB.
Brougham, Thomas
Buchanan, G. J. L.
Campbell, Fred. A.
Campbell, H. A. B., CB.
Carleton, H. A., CB.
Cox, C. Vyvyan
Crofton, Richard H.
D'Aguilar, C. L., CB.
Dalton, Charles J.
De Teissier, H. P.
Devereux, Hon. G. T.
Dixon, W. M. Hall
Domville, Jas. Wm.
Eaton, Gerard P.
Eardley-Wilmot, F. M.
Elwyn, Thomas
Forster, Henry, *bg*
Francklyn, J. H., CB.
Gambier, G., CB., *D.-A.-G.*, *VP.*
Gardiner, H. L.
Gilbert, W. R.
Goodenough, H. Philip
Graham, Allan H.
Grant, E. F.
Hamilton, A. G. W.
Hamilton, F. S.
Hammond, H.
Haultain, F. W.
Kaye, Edward, *bg*
Kemball, Sir A. B., CB., KCSI.
Kennedy, G. R. H.
Knox, Thomas
Lefroy, John H., *bg*
Lewis, Henry
Maberly, Evan, CB.
Maclean, Peter
Marriott, T. B. F.
Maude, F. C., CB. 𝔙ℭ
Maude, G. A., CB.
Maxwell, William
Morgan, Evan
Phillpotts, A. T.
Price, Edward, CB.
Radcliffe, Robert P.
Romer, R. Corcyra
Rowan, Henry S., CB.
Sandham, G.

Selby, George
Shakespear, G. B.
Shakespear, J. D.
Simpson, G. W. Y.
Smyth, John Hall, CB.
Smythe, Wm. James
Spencer, Hon. R. C. H.
Tylee, A.
Ward, Francis B.
Wodehouse, Edwin, CB.
Woollcombe, J. D., CB.
Worgan, John
Wray, Edward, CB.
Wright, Charles J.
Wynne, C. R.
Younghusband, C. W.

LIEUT.-COLONELS.

Anderson, D. G.
Anderson, J. R., CB., *c*
Anson, A. E. Harbord
Arbuthnot, Charles G.
Atlay, Edward
Barnett, Wm. Townsend
Barstow, George
Barton, C. J.
Bent, Hugh
Biddulph, M. A. S., *c*
Bond, F. W., *c*
Boothby, John G.
Bourchier, G., CB., *c*
Bowie, C. Vincent
Boxer, E. Mourrier, *c*
Brown, G. G.
Cadell, A. Todd, *c*
Campbell, James
Chandler, George Lee
Chermside, Henry L.
Clerk, Henry, *c*
Clifford, Miller, *c*
Colclough, George
Connell, Adolphus Ford, *c*
Conybeare, Frederick
Couchman, E. H.
Cox, W. Hamilton, *c*
Desborough, John, *c*
Dixon, M. C. 𝔙ℭ *c*
Dumaresq, W. Lovelace
Du Plat, Charles Taylor, *c*.
Elgee, J. Lindredge
Evans, Charles R. Ogden
Field, George Thomas
Fisher, E. Henry, *c*
Forde, M. Bligh
Franklin, C. T., CB., *c*
Fraser, Hon. D. M., *c*
Freeth, R. King
Gage, Hon. E. T., CB., *c*
Gibbon, James R., CB., *c*
Gleig, Alex. Cameron
Gordon, S. E., CB., *c*
Gosling, W. C. F.
Grant, W. J. Esten, *c*
Green, A. Pellett S., *c*
Greville, H. L. F.
Haggard, T. T.
Hamley, E. Bruce, *c*
Hastings, Francis William
Hatch, William Sparkes, *c*
Hawkins, A. Cæsar, *c*
Henry, C. Stuart, CB., *c*
Heyman, Henry
Holmes, G. B. B.
Hoste, D. E., CB.
Hutchinson, C. H., *c*
Inglefield, S. H. S.
Jervis, H. J. W.
Johnson, George V., *c*
Kinloch, David J.
Lennard, J. F.
Lennox, A. Frederick F.
Leslie, George
Light, Alfred
Longden, C. Scudamore, *c*
Lovell, C. N.
M'Crea, R. Barlow, *c*
Mann, W. Stuart
Maxwell, H. H., *c*
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Milman, G. H. L.
Milward, T. W.
Moubray, E,
Mountain, Robert F., *c*
Murray, A. Maxtone, *c*
Newton, Horace P.
O'Connell, Richard, *c*
Ommanney, F. M.
Ord, Frederick Wm. Craven
Phillipps, P. Winsloe
Pigou, Arthur C.
Pipon, P. Gosset
Robinson, Stapylton
Rotton, Guy, *c*
Shaw, George
Sladen, J. R.
Smyth, Henry A.
Stallard, Samuel
Stewart, A.
Strange, H. F., CB., *c*
Talbot, Robert, *c*
Thompson, Arnold, *c*
Thring, J. E.
Travers, J. F. E.
Tupper, G. Le M.
Turner, John, CB., *c*
Vesey, George H.
Voyle, George E., *c*
Wallace, Hill, *Ast.-Adjt.-Gen. Bombay*
Watson, J. E.
Williams, E. A., CB., *c*
Wintle, Alfred, *c*
Woodcock, C. S., *c*

Scott, Rev. M. R.

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Addington, Hon. Leonard A.
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Anderson, James H. P.
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Armstrong, H. L.
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Baker, R. Aufrere
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Barlow, William R.
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Basevi, Charles E.
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Baylay, Frederick, *adjt.*
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Berthon, T. P., *adjt.*
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Bishop, H. Parlett, *m*
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Blackwell, James E.
Blackwood, George F.
Blair, Gustavus F.
Blunt, Arthur
Bolton, Edward C.
Bolton, John L., *m*
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Bonham, John, *m*
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Borton, Henry M.
Boyle, Edward V.
Boylin, W.
Brackenbury, C. B.
Brackenbury, Henry
Bradford, W. J.
Brancker, William G.
Bredin, Edgar G., *m*
Brendon,, Algernon, *m*
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Broadrick, Edward
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Browne, Charles O.
Bruce, Edward J.
Budd, George
Budgen, William T.
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Burnaby, Alexander D., *adjt.*
Burnett, Edward S.
Burt, Charles E., *m*
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Cairnes, Robert J.
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Calvert, A. M., *m*
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Carey, William
Carey, William Dobree
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Davis, Gronow, VC *m*
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De Moleyns, T. A.
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De Vismes, Henry A. D.
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Dillon, Hon. R. Villiers
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Drayson, Alfred W., *m*
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Dunlop, Samuel
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Dyer, Henry C. S., *m*
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Elliott, E. D.
Ellis, Wilmot B. E.
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Eveleigh, J. E.
Farmer, R. Onslow
Farrell, Henry C., *adjt.*
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FitzGerald, M. M.
FitzHugh, H. T., *lc*
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Ford, John
Forster, Bowes L., *m*
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Franklen, Charles R.
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Frith, J. S., *m*
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Geary, H. Le Guay, *adjt.*
Gilmour, Charles D., *adjt.*
Gilmour, Wallace
Girardot, Henry
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Gloag, H. D.
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Goodenough, W. H., *m*
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Gorham, Charles A.
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Gray, W. John
Greene, D. Sarsfield, *m*
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Grimston, Walter J.
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Harris, Noel H.
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Hay, R. J., *m*
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Henry, G. C., *lc*
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Hickes, H. J. F. E., *m*
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Hill, Peter E.
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Holcombe, F., *m*
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Howlett, Frederick
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Hughes, T. E., *m*
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Joyce, Leonard S.
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Keate, Edward
Kelly, John
Kemmis, William
Kerrick, W. D'Oyly
Ketchen, Isaac
King, Augustus Henry
King, John R.
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Kirkman, William P.
Knox, George U.
Kyle, Samuel C.
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Leishman John T.
Le Mesurier, Cecil B.
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McNeill, John, *adjt.*
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Manderson, G. R., *adjt.*
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Marvin, W., *m*
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Montague, W., *m*
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Munro, Hector

Murdoch, William W.
Murray, A. H.
Murray, Henry
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Newall, Maurius C.
Newbolt, Robert H.
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Newman, Walter
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Nicolls, Oliver H. A.
Nicholson, S. J.
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Noble, William Henry
O'Connor, George
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Oliver, John R.
Ommanney, M. W.
Orr, Andrew
Ouchterlony, T. H., *adjt.*
Owen, Charles H., *lc*
Palmer, Edmund, *m*
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Pasley, M. W. B. S.
Pasley-Dirom, T. A.
Pearse, Arthur T. G.
Pearse, G. G , *m*
Peile, John H.
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Penny, Stapleton
Pennycuick, J. F., *lc*
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Phelips, R.
Phillips, Charles
Phipps, Ramsden W.
Pickering, Charles H.
Pitt, Henry D.
Pitt, Thomas H.
Pope, Robert
Porter, Henry R.
Price, John, A.
Purvis, H. M. G.
Raikes, Charles
Ravenhill, Frederick G.
Rawlins, A. M.
Reilly, W. E. Moyses, CB., *lc*
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Rice, Walter B.
Richards, W. P., *m*
Richardson, John B.
Rideout, Arthur K.
Ritchie, John
Roberts, Charles F., *m*
Roberts, F. Sleigh, 𝔙𝔆 *m*
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Rogers, H., *m*
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Ross, W. A.
Rotton, Arthur
Rowley, R. H. Ricketts
Ruck-Keene, John E.
Ryan, Edward H.
Ryan, Thaddew
Sadleir, Richard
Sandham, Robert, *adjt.*
Sandham, W. H.
Sandilands, Philip H., *adjt.*
Sankey, M. C., *m*
Saunders, W. Boyd, *m*
Schalch, Andrew, *m*
Schreiber, B. F.
Scott, Charles E. S.
Seccombe, Thomas S.
Shakerley, G. J.
Shakerley, H. Webster
Sievwright, Allan
Simpson, W. H. R., *m*
Sinclair, James, *lc*
Singleton, John, *lc*
Slessor, Edward A.
Smart, George J.
Smith, C. H., *c*
Smith, Francis M.
Smith, Jones J.
Smith, Robert C.
Smith, William
Smyth-Windham, J. C.
Soady, France J., *m*
Spurway, John, *m*
Staveley, Edmund
Stevenson, R. A.
Stewart, Hon. Alex., *adjt.*
Stewart, Algernon A.
Still, Thomas L., *adjt.*
Stirling, Charles E.
Stirling, William, *m*
Stocker, Maurice, E. C.
Stokes, Oliver Robert
Stoney, Francis S.
Strahan, William
Strange, T. Bland
Strangways, W. A. F.
Straubenzee, Turner V.
Strover, Henry, *m*
Stubbs, F. W.
Studdy, T. J. C. A.
Swinton, Anson
Talbot, FitzRoy S.
Talbot, Henry L., *m*
Tarleton, Edward D.
Taswell, Edward, *m*
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Taylor, George K.
Taylor, M. Le Fer
Teesdale, C. C., CB., 𝔙𝔆 *m*
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Thornhill, Henry
Thornton, Henry J.
Thurlow, Edward H.
Tillard, John A.
Timbrell, H. V.
Torriano, Charles E.
Tottenham, R. Loftus
Tracey, Harry A.
Traill, George B., *adjt.*
Tremlet, Edmund J.
Trench, Charles
Trevor, Francis C.
Tufnell, Vincent F.
Tulloh, J. S., CB., *m*
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Turbervill, Thomas P.
Turner, Alfred E.
Turner, E. P. B.
Turner, N. O. S., *c*
Tweedie, Michael
Twiss, Arthur W.
Twiss, Godfrey
Tyler, Charles J.
Vachell, H. T.
Vaughan, Ernest C.
Vibart, James, M. C.
Wake, A. J.
Walcott, C. E., *lc*
Walker, E. W. E., *m*
Waller, Wm. N.
Walsh, Lewis P.
Walton, Wm., M. B.
Ward, Edward J.
Ward, F. W., *adjt.*
Wardell, Wm. H.
Warren, F. G. E.
Warry, Edward T.
Watson, Wm. Henry
Webber, Horace H.
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Whinyates, Francis A., *adjt.*
Whinyates, F. Thomas
Wilkinson, J. Allix.
Williams, Albert H. W.
Williams, Wm. J., *lc*
Wilson, C. S. Varden
Wilson, Charles W.
Wilson, William, *m*
Wilson, Willoughby J.
Wolfe, William M. S.
Woodward, W. W.
Woolsey, O'Brien B.
Wortham, Hale Y., *adjt.*
Wyllie, Wm. A. P.
Yates, Henry P., *c*
Yonge, William L.
Young, Charles, F., *m*
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LIEUTENANTS.

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Alexander, John H.
Alexander, W. Stuart
Allan, Dudley N.
Allen, George B.
Alleyne, James
Almon, Edward
Alves, John M.
Anderson, Archibald J.
Annesley, Oliver F. T.
Arbuckle, B. Vaughan
Archer, Fred. L.
Armytage, Arthur H.
Auchinleck, Wm. H.
Baddeley, Paul F. M.
Bainbridge, Edmond
Barclay, Pringle D.
Baring, Evelyn
Barker, Henry A.
Barron, Harry
Bayly, George C.
Bazett, Richard
Beadnell, Charles E.
Beaty-Pownall, G. A.
Bell, James L.
Bent, Charles
Bernard, J. Walker
Best, George
Bevir, Edward L.
Bigg, Frederick

Bircham, Francis T.
Black, W. Campbell
Blackley, John H.
Blackwood, Price F.
Blandy, W. Poyntz
Bomford, Samuel S.
Bonnor, Benjamin J.
Bouwens, Lambert H.
Bowen, H. St John C.
Bowen, Philip H.
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Bridges, J. Strachan
Bridges, T. Walker
Brinkley, Francis
Broadfoot, Archibald
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Browne, H. R. Yates
Browne, James H. G.
Browne, Hardinge W.
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Campbell, John A.
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Carr, Theodore
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Cresswell, Charles A.
Cripps, Edmund W.
Crofton, Henry
Crosthwaite, Charles
Cruickshank, A. Ramsay
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Cumberlege, Archibald F.
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Cunningham, A. B.
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Day, John
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De Marylski, Robert
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Denny, Henry A.
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Deshon, Charles J.
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Disney, Thomas R.
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Dixon, Charles F.
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Downes, Leonard
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Dugdale, Arthur G.
Dunlop, Henry D.
Dunnage, Arthur J.
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Ellaby, Hugh L.
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Freeth, Sampson P. F.
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Gaimes, Herbert F.
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Grant, Robert H.
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Graves, Henry A.
Graves, W. Perceval
Greenfield, John T.
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Greig, Banks R.
Grey, C. F. B.
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Gye, Lionel
Gyll, Flemyng G.
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Hallett, F. C. Hughes
Hallett, Wyndham H.
Hamilton, Charles H.
Hamilton, Constantine H.
Hamilton, Thomas B.
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Harness, Arthur
Harrison, Pemberton
Harrison, William J. R.
Harvey, Charles S.
Harvey, H. B. R.
Haverfield, H. W. B. T.
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Hay, Edward O.
Hayes, Matthew H.
Hazlerigg, T. Maynard
Hellard, H. Betterworth
Hemans, Willoughby B.
Hewitt, J. R. S. O.
Hezlett, Richard J.
Hickson, James Robert C.
Higginson, Henry S.
Hime, Henry W. L.
Hitchins, Thomas M.
Holbeche, Robert N.
Holley, Edmond H.
Hollist, Edward O.
Hopkins, Samuel
Hornsby, George M. B.
Hubback, Henry W. J.
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Hunter, Woodburn
Hutchinson, William F. M.
Hutchinson, William Lacy
Huyshe, D. Fraser
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Innes, Francis Newell
Irwin, Thomas de la C.
Isaacson, H. de Stuteville
Isacke, H. Wedderburn
Jesson, Thomas
Johnson, Edward A.
Johnson, Frank
Jones, Charles
Jones, Douglas F.
Jones, Henry N.
Jones, Thomas J.
Joseph, Frederick W.
Josselyn, James E.
Kelsall, Thomas A.
Kelso, John A.
Kempster, William H.
Kennedy, George M.
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Kingscote, H. B.

Kinsman, Harold J.
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Lake, Edward
Lane, M. M.
Lanning, Robert A.
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Lawrie, James A.
Leacock, Charles E. B.
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Legard, James D.
Legge, W. Vincent
Le Grice, Frederick S.
Le Marchant, H. St J. Thomas
Le Mottée, Osmond F.
Lewes, Price
Lewis, Henry F. P.
Little, Francis L. G.
Lloyd, Francis T.
Lloyd, Thomas H.
Loch, James
Lockhart, Robert D. E.
Lockyer, Edmund S. B.
Lodge, Frank
Logan, Alfred
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Lowis, Ross F.
Macdonell, George B.
Mackenzie, Robert S. M.
Mackey, Hugh A.
Mackinlay, George
Mackintosh, William J.
Maclachlan, Kenneth F.
Maclean, Allen H.
Macpherson, C.
Magenis, Henry C.
Mainwaring, Alfred R.
Mallins, Williams
Mallock, Richard
Marshall, Edwin
Marshall, George H.
Marshall, R. G. S.
Martelli, Thomas C.
Martin, George B. N.
Martin, William
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M'Clintock, William
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Milner, Frederick H. W.
Molesworth, A. Oliver
Molesworth, St Aubyn
Montgomery, George
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Morgan, Harrison R. L.
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Morley, Clervaux
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Pipon, Henry
Platt, Wadham P.
Plunkett, R. H. W.
Poole, Joseph R.
Poole, William S.
Porter, Morton L.
Power, Gervaise B.
Pratt, Sisson C.
Pretyman, George T.
Price, Robert L.
Price, Thomas C.
Prior, Adrian de M.
Pym, Samuel
Radford, Arthur
Rainsford-Hannay, R. W.
Rait, Arthur J.
Ramsay, George S.
Rawle, Henry J.
Rawlins, A. J. C.
Reeves, Thomas B.
Rennick, Robert H. F.
Revill, John
Riall, William A.
Richmond, Felix
Riddell, Walter
Roberts, Francis
Roberts, Howland
Roberts, T. W.
Roberts, W. Arthur
Robertson, Henry M.
Robertson, Robert H.
Robinson, Francis M.
Robinson, John C.
Robson, John C.
Rogers, John P.
Rooke, Harry W.
Ross, Robert H. K.
Rothe, G. Walter C.
Rothwell, John S.
Rudge, Samuel
Rudge, Walter R.
Rule, Charles G.
Russell, Francis B.
Sale, Wm. Henry B.
Salmond, John M.
Sandeman, Julian F.
Sandes, H. T. T.
Sandys, Claude B.
Sandys, Edwin W.
Saunders, Augustus J.
Saunders, Arthur A.
Saunders, Joshua M.
Saunders, Robert P.
Saward, Michael H.
Scott, William
Sealy, Charles W. H.
Sexton, Michael J.
Shafto, Edward D.
Sharp, W. E.
Shea, Henry J. F.
Sheil, Henry
Shippard, Walkinshaw O. C.
Shore, Hon. F. W. J.
Shuttleworth, Ashton J.
Simpson, Simon
Skinner, P. L. Mac Gregor
Slade, John R.
Sladen, Joseph
Smith, Charles M.
Smith, Robert W.
Smith, Stuart
Smith, William O.
Smith, W. Whitmore
Smith, Walter W. M.
Smithett, Albert L. C.
Snodgrass, John D.
Soames, Henry
Sorell, William H. F.
Souper, Charles E.
Spragge, Charles H.
Spring, F. W. M.
Stace, Edward V.
Stedman, Edward
Stephenson, Keppel
Stevens, George M.
Stevenson, Henry
Stewart, Charles
Stewart, Henry T.
Stewart, Hugh
Stewart, R. M'Gregor
St George, William B.
Stirling, Walter G.
Stone, John G.
Strahan, George C.
Stratton, John H.
Stirke, William R.
Sutton, George F. D.
Symonds, Frederick C.
Tabor, John M.
Talbot, Adelbert C.
Tatham, Walter J.
Taylor, Duncan N.
Taylor, John
Taylor, Lewis W.
Thompson, Charles H.
Thompson, Robert
Thomson, Charles W.
Thornhill, Charles
Tillotson, Lionel

Tollner, Barrett L.
Toogood, Seymour H.
Torkington, Henry
Townsend, C. William
Townsend, George E.
Tupper, Basil de B.
Turnbull, George W. M,
Turnbull, H. J. Lennox
Turner, Alfred E.
Turner, Frederick M.
Twynam, Frederick R.
Tyler, Trevor B.
Tyzack, Joseph D.
Uppleby, J. G.
Vibart, Francis M. E.
Wace, Richard
Wainwright, C. B. F.
Walford, Neville L.
Walker, Thomas
Walkey, Rowland
Wall, James
Wallace, Robert H.
Warburton, Robert
Warren, William A.
Warry, Arthur
Watkin, Henry S. S.
Watson, Robert S.
Wemyss, Maynard W.
Weston, Frederick L.
Whalley, Percy C.
Whateley, William
Whinyates, A. W. O.
White, Arthur W.
Wickham, Charles B.
Wickham, Edmund H.
Williams, H. Lluellyn
Williams, Richard F.
Willis, Horace G.
Wilmer, John R.
Wilson, Dudley M.
Wilson, George F.
Wing, Vincent
Winn, E. J.
Wintle, Alfred T.
Wodehouse, Albert T.
Wood, Thomas
Woodland, V. Reynolds
Woollcombe, Edward
Wright, W. Henry
Wymer, G. B.
Wynne, George C.
Yaldwyn, Burton
Yates, Henry T. S.
Yeatman, Arthur G.
Yerbury, John W.
Yorke, Frederick A.
Young, Henry G.
Young, John M.
Younger, John

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Daley, Jeremiah
Dann, George
Donald, William
Ritchie, Thomas

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Hunt, T., *capt.*
Kidd, William A., *m*
Piers, Cladius B.
South, C., *m*
Stewart, Donald, *lc*
Thompson, J. B., *capt.*
Vyner, H. W., *capt.*

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Cochran, John, *com. st.*
Fyfe, John
Gibson, Thomas
Marvin, George, *com. st.*
Nelson, Henry
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Gaye, Arthur C.
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Griffith, Charles W.
Hodgson, D. F. de, MD.
Hogg, F. R., MD.
Jones, Melville G.
McFarland, Francis E.
O'Leary, E. F.
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Prescott, Albert S. K.
Richmond, Alexander
Sly, William
Tanner, William
Tate, George R., MD.
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Meyrick, James J.
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EXPERIMENTAL CASEMATES AT SHOEBURYNESS.*

[Published by Authority of the Secretary of State for War.]

Result of preliminary fire, 18th May, 1865, against the experimental granite casemate erected at Shoeburyness, for the purpose of testing the effect of modern artillery on the piers between the iron shields of the casemated works.

R.G.F. 9·22-in. experimental gun of 12 tons., 2 cwt., 2 qrs., made in 1864.

		Length. ins.	Diameter. ins.	
Charge	30·25 lbs.	19·0	7·75	Representing full charge of 44 lbs. at 1000 yards range.
	39·00 „	19·5	8·25	„ 600 „

Range 200 yards.

No. of rounds.	Charge.	Elevation.	Allowance for deflection.	Penetration.	Remarks.
	lbs.	′	′	ins.	
1	30·25	2	—	9	Struck inner corner of stone of arch of right casemate breaking three stones. Cracks extending to the left casemate. Concrete on top of piers slightly cracked, and four feet of the new brickwork of parapet dislodged. *Inside* brickwork a little shaken, cracks appearing. Shot broke up.
2	39·00	23	5	18	Struck on joint of 3rd and 4th course. Broke away an area 4′ × 5′ from face of masonry. Centre and lower jamb stone of left casemate moved in towards shield ¾″. *Inside,*—Cracks more numerous and lengthened. Shot rebounded 5 yards, cracked at head and set up.
3	30·25	30	5	24·5	Struck 1 ft. below last. Jambs right and left forced in. Right centre jamb broken 1 ft. 10 in. from shield, and driven in 3 ins.; other jambs variously injured. *Inside,* —brickwork a good deal shaken and cracked, the cracks extending to crown of arch, and centre *pier* much cracked and loosened at sides. The cracks tend upwards and inwards from bottom. Shot broke up.

Rounds 1 and 2. Elongated steel shot, hemispherical head, weight 220 lbs., diameter 9·15 ins., length 13·4 ins.

Round 3. Elongated cast-iron shot, conical head (service shot), weight 218 lbs., diameter 9·15 ins., length 16·0 ins.

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* Extracted from Vol. III. of the Extracts from the Reports and Proceedings of the Ordnance Select Committee.

Report No. 3765 (26/5/65).

The Committee submit the results of the above-mentioned preliminary firing.

The experiment, which was merely preliminary, consisted in firing three rounds from a 9·22-inch muzzle-loading gun of 12½ tons, rifled, against the pier of a casemate of masonry composed of granite facing and brick backing, having a total thickness of 14 feet, which pier was situated between two embrasures, both of which were fitted with iron shields. The work had been executed with the greatest possible care, and in a most substantial manner; the brickwork and masonry were laid in cement.

From the results of the rounds fired it appears that the effect of the very first discharge was to destroy the cohesion of the materials forming the pier fired against; this was evinced by the fracture of the bed joints of the granite blocks from the place struck quite round to the rear of the left embrasure, or that furthest from the place of the blow, and by the fracture which extended upwards internally towards the crown of the arch of the casemate. These fractures were increased, and fresh ones made by the two subsequent shots, the fracture in the brickwork in the rear of the pier becoming by the third shot of a serious nature. The whole key of the pier being thus broken, it may safely be assumed that every successive shot would tell with redoubled effect on the structure, and that a few more rounds striking near the same place would have destroyed the pier. As it was, the pier was so much shaken, that to make it good again it will have to be taken down and rebuilt.

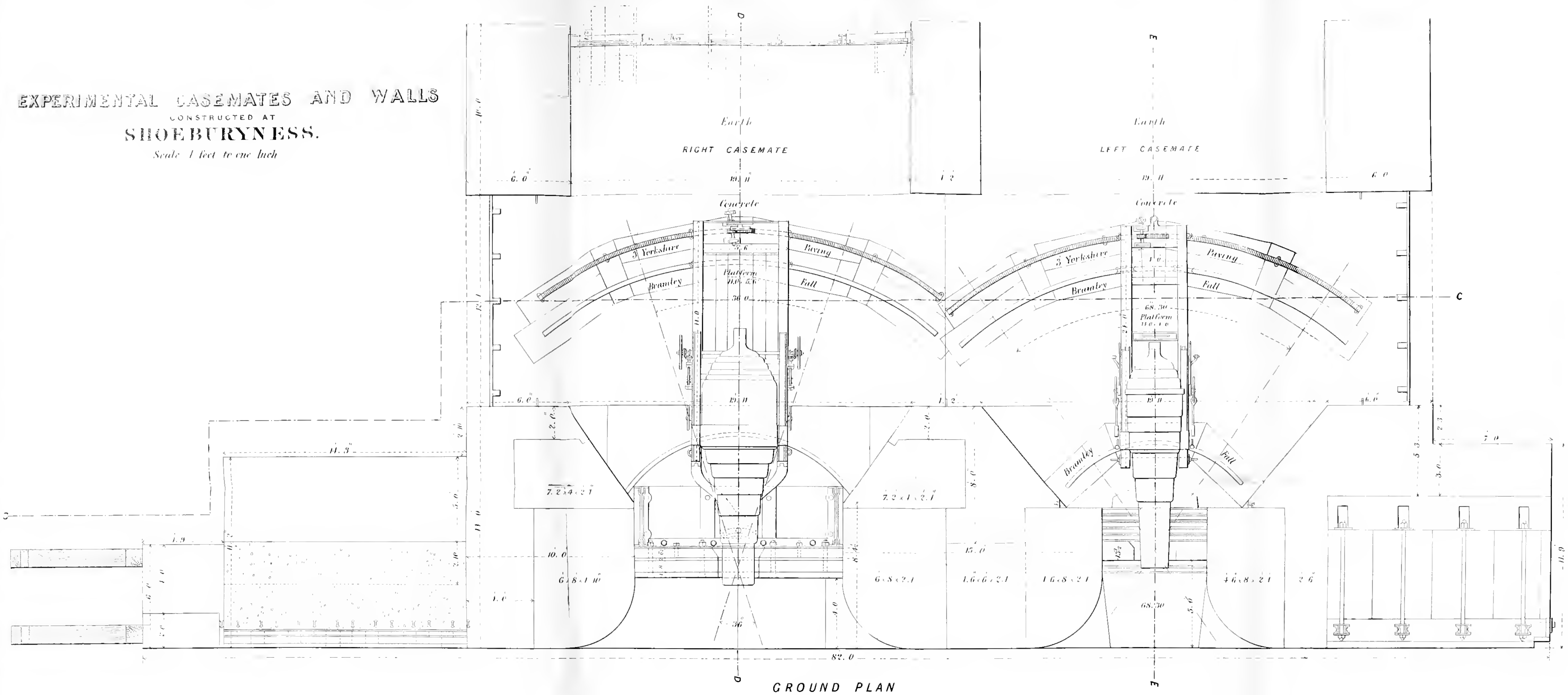
It must be remembered that the security of the upper tiers of guns, so far as depending on any one pier, would be very much compromised, and the ruin of the work accelerated by the concussion of the firing supposed to be going on from within. A casemate, therefore, that shows such a result as that above described, after being hit by only three shots, two of which were fired with charges representing a range of 1000 yards, and only one at 600 yards, would be rendered untenable if struck by half a dozen consecutive shots delivered from a gun of equal power, and it may fairly be assumed that a less number striking simultaneously, or nearly so, would have an equally disastrous effect as regards the immediate locality subjected to them. Generally it may be observed that the experiment, even in its present early stage, tends to prove that a thickness of 14 feet of combined granite and brickwork, is insufficient to hold out against the attacks of vessels armed with guns of similar power to the ones used on the 18th, and that a much increased thickness of masonry (and consequently increased expenditure) would be necessary to enable a masonry fort to cope for any length of time successfully with heavily armed ironclads, supposing them capable of resisting the artillery of the fort. This element of the question is one into which the Committee are not called upon to enter. It is sufficient for them to remark that the whole of the shot which struck the pier would have passed through the side of the "Lord Warden," one of the very strongest vessels yet built, that effect having been produced on the 17th June 1864, by two steel shot of 221 lbs. fired with 30 lbs., with apparent ease.

EXPERIMENTAL CASEMATES AND WALLS

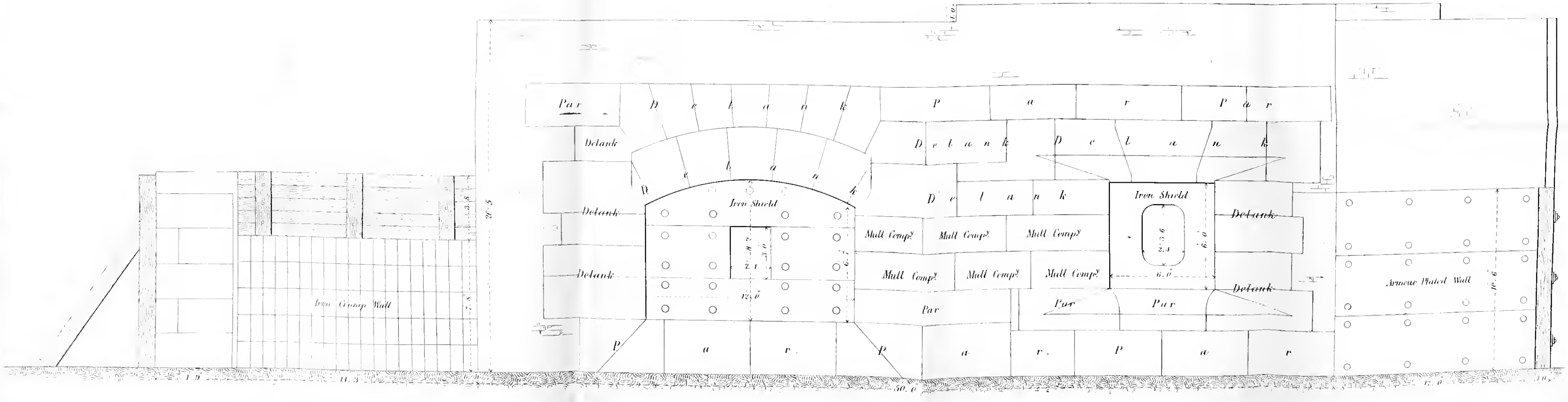
CONSTRUCTED AT

SHOEBURYNESS.

Scale 4 feet to one Inch



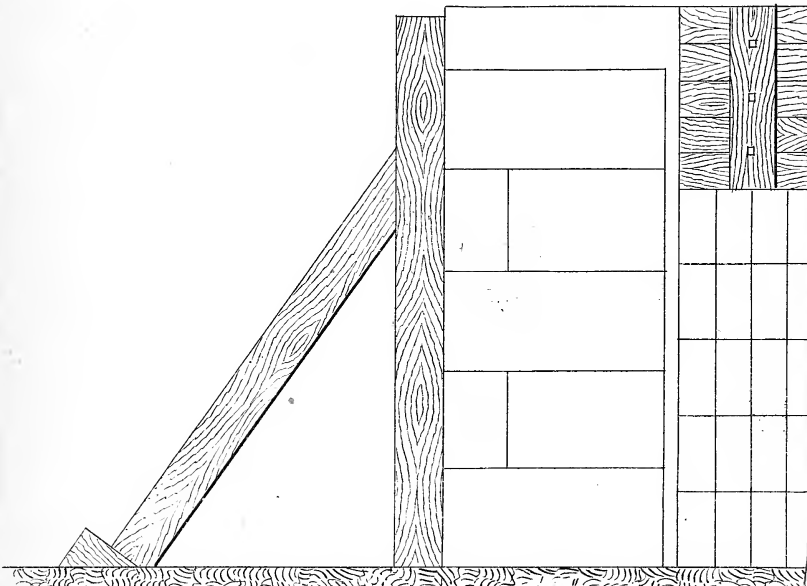
GROUND PLAN



FRONT ELEVATION

EXPERIMENTAL CASEMATE

CONSTRUCTED AT

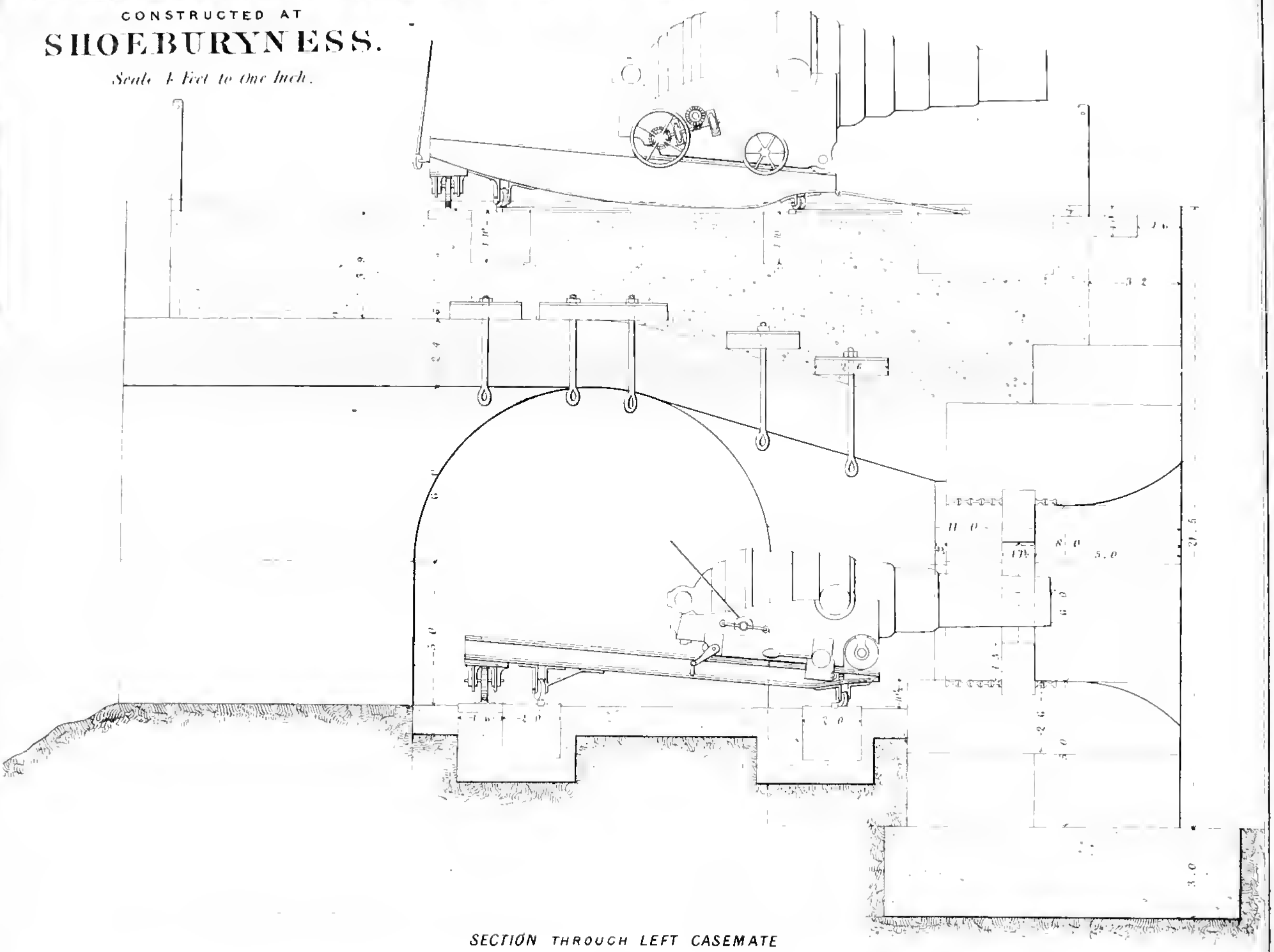


EXPERIMENTAL CASEMATES AND WALLS

CONSTRUCTED AT

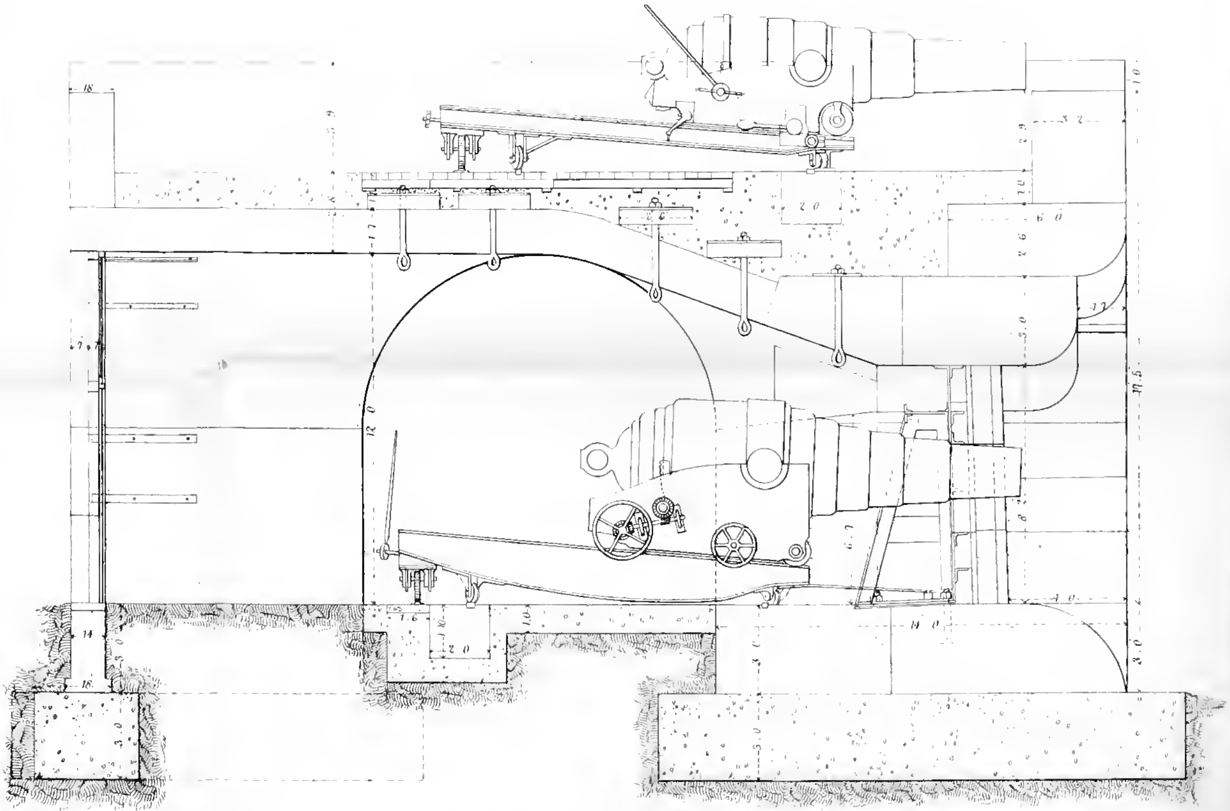
SHOEBURYNESS.

Scale 4 Feet to One Inch.



SECTION THROUGH LEFT CASEMATE

On line E. E.



SECTION THROUGH RIGHT CASEMATE.

On line D D.

Day & Son Limited lith.

The quantity of granite actually knocked off, or so splintered as to be easily picked out, amounted to about 4060 lbs, to which an addition of about 5 per cent. or another 120 lbs., may perhaps be made for dust and small splinters so dispersed that they could not be collected.

Report No. 3991 (12/12/65).

The Committee have the honour to report their further experiments upon the granite casemate and iron shields erected at Shoeburyness in 1864, and which have been framed with a view—

(1) To ascertain the quantity and weight of fire from heavy rifled guns required to render such a structure indefensible, and (2) To enable a judgment to be formed on the relative value of granite and iron as applicable to the construction of works of defence.

2. The work subjected to attack represented two adjacent casemates on the ground tier of a fort, with their embrasures protected by iron shields. It was built of granite, in blocks of considerable size, which were disposed in seven courses. The largest block in the structure contained 104 cubic feet, the smallest 29 cubic feet. They would weigh about 7·7 and 2·2 tons respectively.

The whole was surmounted by a parapet wall of brickwork 3 feet 2 inches thick, and 3 feet 9 inches high.

The total frontage of granite was 43 feet to 46 feet (being different on different courses of stone).

	ft.	in.
Height of do.	16	8
Height, including brickwork	20	5
Greatest thickness of granite in the piers ...	12	0
Least thickness	8	0
Total thickness including brickwork	14	0

The vault over the right or east casemate, which represented an intermediate floor, was turned in four rings of bricks, total thickness 1 foot 7 inches, and was surmounted with a platform of concrete whose greatest thickness was 3 feet 6 inches. There was altogether 5 feet 6 inches of granite and 1 foot of concrete immediately over the shield; the total thickness over the vault was 2 feet 8 inches.

The vault over the left or west casemate was intended to be bomb-proof, and was turned in 6 rings of bricks; total depth 2 feet 4 inches, and surmounted by a platform of concrete 6 feet deep behind the granite, and 3 feet 9 inches deep over the crown of the vault.

The greatest height of the arch of the right or east embrasure was 8 feet 2 inches, length 12 feet. It was closed by an iron shield having an opening or port hole 28 × 36 inches in the centre.

The shield was composed of 3 slabs of rolled iron 4 inches thick, behind which were 8 inches in depth of $\frac{7}{8}$ths inch iron plates placed vertically on their edges, then a 2-inch solid plate, next 6 inches of teak, and finally, a 1-inch iron plate; the whole being bolted together from front to rear and secured to a strong iron girder frame the base of which turned back horizontally, and was strongly attached by nuts to vertical bolts let into the granite.

The total thickness of this shield was 21 inches.

The left or west embrasure was finished in a flat arch, height 6 feet, width 6 feet.

It was closed by an iron shield, having an opening or port hole 28 × 42 inches.

The shield consisted of a solid rolled iron plate 13½ inches thick, manufactured by Messrs Brown & Co. It was secured at top and bottom by iron railway bars, let into the granite in the course of construction, and these horizontal bars were again tied by transverse bars cramped at each end and built into the granite.

The above dimensions are given in general terms.

3. The guns selected for the trial of the casemate were, in respect to calibre and weight, of a class that may be expected sooner or later to enter largely into the general armament of ships of war; none of them exceeded 12½ tons in weight. In these respects, therefore, they were fair representations of the power of an offensive fleet, and the effects produced by them on the structure may be taken as reliable data on which to base an opinion with regard to the comparative advantages of iron and granite (considered as to their powers of resistance only), as material for the construction of works of defence.

The guns, projectiles, and charges were as follows:—

Calibre.	Weight.			Charge.		Weight of shot.	Striking velocity.	
				600 yds.	1000 yds.		600 yds.	1000 yds.
ins.	tons.	cwt.	lbs.	lbs.	lbs.	lbs.	ft.	ft.
10·0	12	2	57	41·3	36·0	280	1273	1209
9·22	12	2	56	39·5	30·25	220	1395	1322
8·00	6	19	50	26·0	22·0	150	1369	1292
7·00	6	19	72	18·0	—	115	1370	—

4. The battery was placed at 200 yards from the casemate, but the charges were reduced to give a striking velocity equivalent to 1000 yds. and 600 yds. range, with the full service charges.

The fire was opened on the 16th November, commencing with one round of solid steel shot from each gun against each shield.

5. The results, so far as they can be traced before the debris are cleared away, may be stated in general terms as follows:

The compound iron and wooden shield in the east embrasure was struck fair by 13 shots, viz.:—

			yds.		foot tons.
7″·0	steel shot	with velocity due to	600	1	1497
8″·0	〃	〃	1000	1	1736
9″·22	〃	〃	1000	1	2666
9″·22	〃	〃	600	2	5938
9″·22	cast-iron shot	〃	1000	1	2666
9″·22	steel shell	〃	600	1	2969
10″·0	steel shot	〃	600	4*	12,584
10″·0	〃	〃	1000	2	4257
				13)	34,313

Average blow ....2639 foot tons.

With the exception of a small piece which has been cut out of the lower sill, and the loss of about 3 square feet of the exterior plate which is broken off the right top corner and leaves the edges of the vertical plates exposed, this shield, although presenting a very battered appearance, is substantially entire.

It is, however, cracked through and through. Out of 37 armour bolts with their nuts and washers for securing the shield to the girder frame 11 are gone, as are the greater parts of the rivets of the frame itself; these would have formed splinters of a dangerous character; one bolt weighing 25 lbs. was thrown 28 feet to the rear. The shield is still in a condition to shelter a gun detachment, and would apparently stand several more blows.

The mode by which the girder supporting the shield is attached to the granite floor, namely by 10 bolts passing through a sole plate, has proved sufficient for the purpose.

It has budged very little, but sufficiently so to have disturbed the pivot of the gun behind it, which became unserviceable after seven blows on the shield. The inner skin is rent in several places, but no portion of it has come away.

6. The rolled 13-inch iron plate in the west embrasure was struck by 9 blows; viz.

			yds.		foot tons.
7″·0	steel shot	with velocity due to	600	1	1497
8″·0	〃	〃	1000	2	3472
9″·22	〃	〃	1000	1	2666
9″·22	〃	〃	600	1	2969
9″·22	cast-iron shot	〃	1000	1	2666
10″·0	steel shot	〃	1000	1	2838
10″·0	〃	〃	600	2	6292
				9)	22,400

Average blow......2489 foot tons.

This shield then, has received about two-thirds as much battering as the other, but considering that its surface is only one-third of the surface of the other, it may be said to have had the more severe trial of the two. It

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* Half value is added for No. 1054, which glanced off the pier on to the shield.

is completely cracked through in two places and a portion on the left side between the two cracks appears ready to come away with a blow. It did, however, receive a blow from a 10-inch steel shot partly on the separated piece after it was cracked through without giving way.

7. The Committee had intended further fire on both shields, but their steel shot are exhausted.

It is to be observed that the simple rolled iron plate possesses an important advantage in having no bolts, nuts, washers, or rivets to cause casualties in the work.

The west shield owes its attachment entirely to a system of bars of railway iron built into the granite and held by other similar bars crossing them and turned down as cramps. There are 10 of these cramping bars above and below, of which 5 are broken.

This mode of fastening appeared amply secure, and it is perhaps the only way in which a thick plate in one mass can be held, but it has the disadvantage as compared with that employed for the other shield, that it forms a part of the structure, and there would be no means of replacing a wounded shield without extensive pulling down of the interior.

8. Considered as an embrasure the opening into which the west shield is inserted has the disadvantage of deflecting in shot that strike outside of it.

The Committee ascertained this by firing five 40-pr. segment shells so aimed as to impinge on the granite from each surface, right, left, under, and over. In every case some of the splinters or segments entered the casemate by the embrasure.

In one case the quantity that got in was sufficient to have been very destructive to the men both in the casemate struck and in the adjoining one, the segments having glanced off at an angle of about 45°.

The marks on the wooden screens were so close and so numerous as to make it difficult to count them.

The east embrasure, which is 12 feet wide, is not liable to these casualties and was therefore not put to the same test.

The Committee do not think any iron shield should be less than 12 feet wide when recessed in stone openings of the general character of those they have tried.

9. The centre pier or space between the embrasures received on this occasion 19 blows, and had previously received 3,* total 22; viz.:—

		yds.		foot tons.
7″·0	cast-iron shot	600	2	2994
8″·0	"	600	2	3898
9″·22	"	1000	1	2666
9″·22	steel shot	1000	1	2666
9″·22	"	600	1	2969
9″·22	cast-iron shot	600	2	5938
9″·22	steel shell	600	1	2969
10″·0	cast-iron shot	600	12	37,752
			22)	61,852
		Average blow......		2811

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* See Report, No. 3765, p. 70.

The effect of this fire, concentrated upon a space of 185 square feet, has been to bring away nearly the whole of the granite from the exterior, except perhaps the two bottom courses, which being at present buried in debris, cannot be examined.

No. 1132, 9·22-inch steel shell burst in the pier and blew in some of the brickwork and granite, leaving an opening about 18 inches by 30 inches; it caused a large portion of the brick backing of the pier to fall inwards or backwards in a mass, and produced a mass of ruin which it would be difficult to describe.

The sole support of the three arches radiating from this pier appeared to be a narrow bearing of about two bricks on the corner of the granite block behind C2.

Two salvoes were fired at the pier after this. The first was aimed about the level of the top of the shield, and apparently took effect there. It brought down an immense mass of debris, including several large granite blocks out of the upper course entire, and almost hid the remaining pier. It was getting too dark for accurate laying when the second salvo was fired, and from the perceptible augmentation of the opening over the east embrasure, it was suspected that one or two of the shot struck there. The others, however, struck high and about centrally, bringing down all that remained of E, F, and G courses, together with large blocks of concrete. The concrete was now fully exposed over the whole central portion of the work for a width of 32 feet.

It will be impossible until the rubbish is cleared away from the outside and inside to ascertain minutely the state of the structure, nor is it very material to the issue, but it must be remembered that two or three feet of the base of the pier receive a support from the concrete filling in behind, which would be wanting in any complete structure.

10. The granite surface of the work generally received 62 blows, to which are to be added 3 fired on the 18th May. Total 65.

One of these shots did not appear to have actually struck any portion of the granite, but as the shock on graze was sufficient to split the block G5, it is counted.

11. These blows were as follows :—

On the two courses composing the arch over the E embrasure, 12, viz. :—

	yds.		foot tons.
7″·0 cast-iron shot	600	2	2994
8″·0 〃	1000	2	3472
9″·22 〃	1000	3	7998
9″·22 〃	600	1	2969
10″·0 steel shot	600	1	3146
10″·0 cast-iron shot	1000	3	8514
		12)	29,093

Average blow 2424

Some of these shots were fired in two salvoes, one of 7-in., 9·22-in., and 10·0-in. shot. The other of 7-in., 8-in., 9·22-in., and 10·0-in. shot aimed centrally on the same spot.

The effect of these shocks was to bring down the whole of the arch, except so far as supported by the shield, and to shake out the brickwork included between two of the granite stones of the vault inside, and a large portion of one of the arch stones itself, making an opening through which daylight appeared.

The brick vaulting behind, although much fissured and cracked in many directions, remained otherwise entire, but two or three large pieces of granite were detached from the wall and thrown into the work.

The arch stones had been twice struck before the salvoes.

12. The smaller arch over the west embrasure which differs in structure from the other received ten blows, but they were of somewhat higher average value; viz.:—

	yds.		foot tons.
7-in.	0	0	0
8-in. cast-iron shot	600	1	1,949
9″·22 "	1000	8	21,328
9″·22 cast-iron shell	1000	1	2,666
		10)	25,943

Average blow 2594

The effect was to bring down the arch stones and the course of granite above them to a depth of five feet; that is to say, to the plane of the shield which, however, supported what rested immediately upon it, and to expose the concrete of the bomb proof arch.

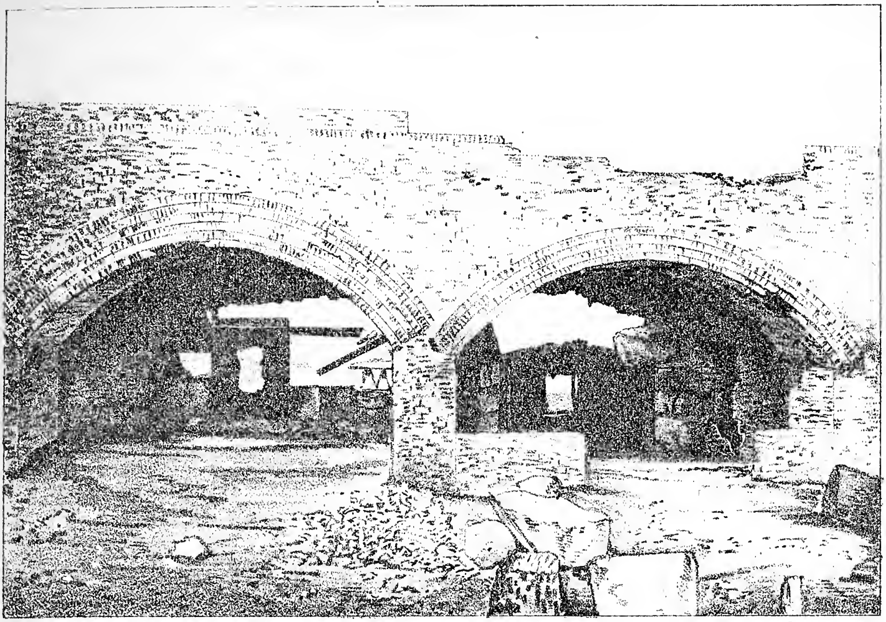
The vaulting inside, although much cracked, remained otherwise entire.

13. The east pier was structurally rather stronger than the west pier, but the former having been weakened by the blow of the 10-inch steel shot, which split blocks C1 and D1 before glancing on the shield, the Committee appropriated the 7-in. gun to its demolition, and took the heavier 8-in. gun for the same work on the west pier. The B and C blocks were demolished externally by the 7-in. gun in ten rounds with charges due to 600 yards range, and the blocks behind them were split, throwing large splinters into the work but without entirely giving way, perhaps half of each may remain on its bed.

The last round fired at it was an 8-inch steel shell. It did not perceptibly increase the damage externally but threw a block of three or four cwt. to a distance of 20 feet across the casemate inside.

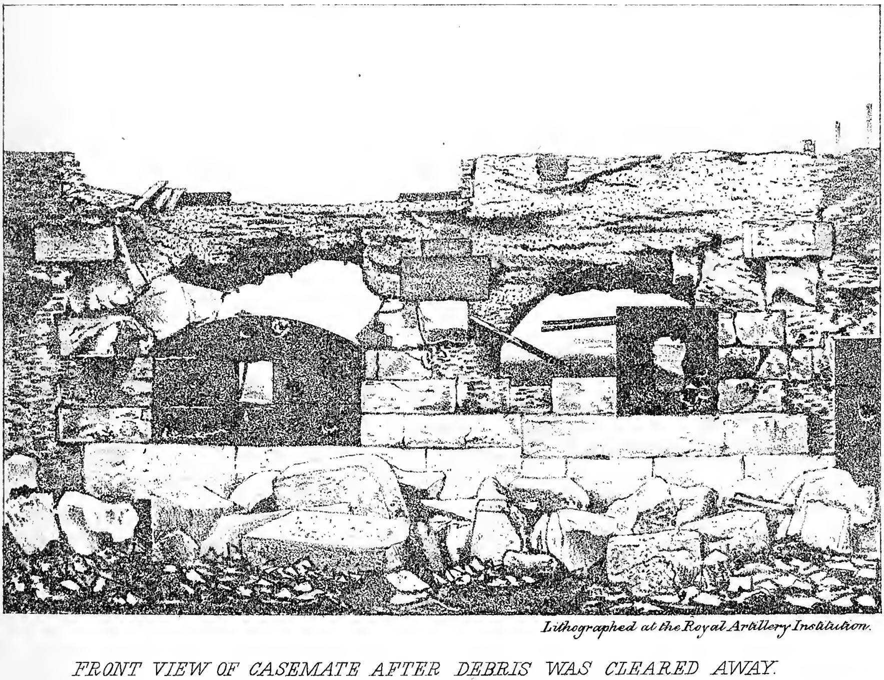
The aggregate value is 18,338 foot tons, the average force 1528 foot tons.

14. The west pier was struck by four 8-in. shot fired with the 600 yards charge before either of the granite blocks was so far cut away as to make an opening into the work. This took place, however, at the fifth shot,



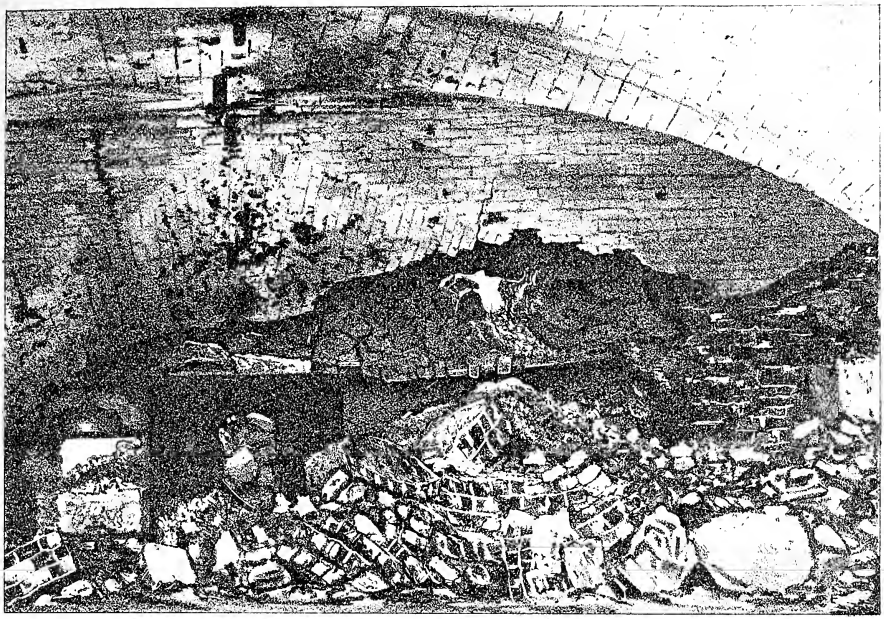
Lithographed at the Royal Artillery Institution.

INTERIOR OF CASEMATE AFTER DEBRIS WAS CLEARED AWAY.



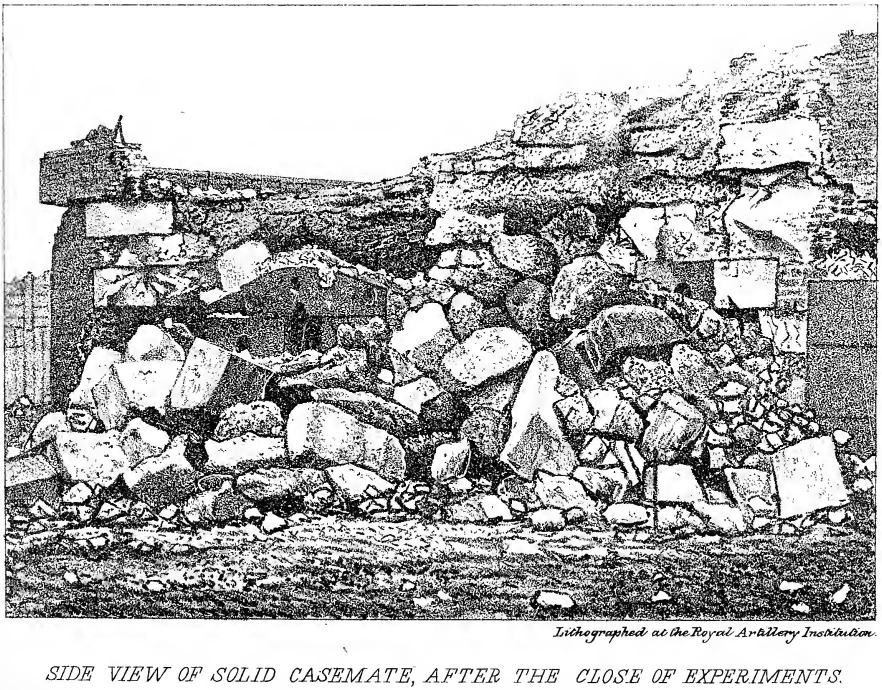
Lithographed at the Royal Artillery Institution.

FRONT VIEW OF CASEMATE AFTER DEBRIS WAS CLEARED AWAY.



Lithographed at the Royal Artillery Institution.

BACK OF SOLID SHIELD AND GRANITE CASEMATE, AFTER THE CLOSE OF THE EXPERIMENTS.



Lithographed at the Royal Artillery Institution.

SIDE VIEW OF SOLID CASEMATE, AFTER THE CLOSE OF EXPERIMENTS.

when the corner of D6 block was forced in, leaving an opening of about three and a half square feet. This hole was enlarged by the seventh shot to six square feet.

The damage was not materially increased in external appearance by two more 8-in. shot, and one 9·22-in. which struck on E course afterwards. The aggregate value is 20,207 foot tons, the average force 2021 foot tons, the whole with the 600 yards charge, except the last.

15. The Committee have now to state the general conclusions they draw from the practice reported.

Both the iron shields have resisted well, and the fastenings of both may be said to be still effective, inasmuch as they have held them in their places to the last; those of the east shield are indeed hardly impaired. Those of the west shield have been weakened by the breaking off of three out of ten iron cramps, but the remainder continue to hold the plate; both shields continue to afford a fair amount of protection to the gun behind them, nor can anything be said to have got through them, although they are cracked through, bent, and started from the effects of the fire.

The east or compound shield (as shown above) has been struck 13 times to an aggregate amount of 34,313 foot tons, or 424 foot tons to every square foot of its actual surface when the port hole is deducted.

The west or simple shield has been struck nine times to an aggregate amount of 22,400 foot tons, or 800 foot tons to every square foot of surface when the port hole is deducted.

Total, 22 blows on the iron.

16. After deducting these 22 blows struck on the two shields, there remain 65 which have struck the granite. They were distributed over a surface of about 514 square feet; for the bottom course, which was not struck, must be deducted. The effect is such a degree of demolition as would have caused the abandonment of the two casemates attacked before the firing ceased. They were noted as beginning to be untenable after the 33rd hit on granite, and quite so after the 54th hit.

With them the casemates in the next tier above, and probably also any barbette guns in the same vertical section must have been also abandoned, the structure being rendered too insecure to allow of their continued use.

The Committee must lay much stress on the irreparable character of the injury done to the stonework; nothing short of complete reconstruction would restore it, whereas a structure of iron would admit of easy repair by re-casing the wounded parts, which always serve as support, and might be actually rendered stronger than before by the accumulation of thicknesses of plate, and it was observed that the dust, grit, and fine splinters of granite sent into the work were sufficient to amount to annoyance, if not to an actual obstruction of the working of the gun.

17. In making any comparison between the protective value of iron, such as was used in these shields, and granite, as a material for fortifications, it must not be forgotten that the proportion between the external surface of the granite and the external surface of the two shields, is that of 514 to 109

square feet, and the total number of shot which struck the granite was 65, whilst the total number which struck the shield was 22; it therefore follows that the blows delivered on iron were as 1 to 5 square feet of surface, whereas they were only as 1 to 7·9 square feet of granite. In point of value they were at the rate of 520 foot tons per square foot of surface on iron, and of only 302 foot tons per square foot of granite, so that, whether considered in regard to the number or the force of the blows, the iron shield received a much more severe battering than the granite wall. The firing at the former, moreover, was almost entirely with steel shot, whilst at the granite cast-iron was almost exclusively used.

18. The superiority of iron does not, however, rest merely upon its shot-resisting power, for, as the Committee have already observed, the destruction of the lower tier of casemates in a granite structure involves the abandonment of the upper and barbette batteries, whilst it is probable that, owing to the enormous strength which must be given to an iron battery to give it sufficient shot-resisting power, there will, even after such an attack as might have rendered the lower casemates untenable, remain more than sufficient strength for the support of the general structure. Finally, the Committee would observe, this experiment has proved that whilst the attack of a properly constructed iron-built battery would be hopeless, except with steel or hardened shot, at a range not much exceeding 600 yards, the destruction of a granite fort may readily be effected with cast-iron shot at 1000 yards.

It is proper to add, that considered as a granite fort with iron shields, the one now reported upon appears not to have been as strong as such a structure might be made with those improvements which the result of the present costly experiment will doubtless suggest to the Department of Works, if any more such works are to be designed. But the Committee have for the foregoing reasons no hesitation in recording their opinion, that granite should if possible not be used in exposed parts of the structure of forts liable to be regularly engaged by heavily armed iron-clads. That when unavoidably used, it should not be combined in the piers with brickwork or any other inferior material in the manner in which it was combined in this structure, and that it would be far preferable to provide forts in such situations with external defences entirely of iron.

The iron-faced flanks have not yet been attacked, and the Committee must wait for a further supply of steel shot before proceeding to do so. This will also afford time for clearing away the rubbish and examining the rest of the structure more minutely.

MEMORANDUM BY THE DEPUTY DIRECTOR OF WORKS, ON THE RESULTS OF EXPERIMENTS UPON A CASEMATED STRUCTURE OF GRANITE, WITH IRON SHIELDS AT THE EMBRASURES, CARRIED ON AT SHOEBURYNESS IN MAY AND NOVEMBER, 1865.

1. Before considering the results of these experiments, I will refer briefly to the successive improvements that have been adopted of late years in casemates for sea defences, and especially in those lately constructed in this country.

Old constructions of casemates.

2. Figs. 1–6, Plate I., and Figs. 1–6, Plate II. represent the construction of casemates and embrasures adopted in the sea defences of the principal ports of the chief maritime powers previous to the year 1861. The dimensions of the embrasures will be seen on the plates.*

The front walls of these defences have been constructed in some places of the stone of the locality, in some cases faced with granite; in places where stone is comparatively costly, they have been built wholly of brickwork.

English.

3. Excepting the old castles of the time of Henry VIII., at Portland, Walmer, Deal, and Hurst, &c. the only casemated sea defences which have been constructed in this country previous to the last five years, are at or near Portsmouth. Blockhouse Fort and the Point Battery (see Figs. 1, 2, Plate I.), on either side of the entrance to the harbour,—part of Fort Monckton,—and a work at Cliff End, Needles Passage (see Figs. 3, 4, Plate I.), are casemated.

Except at Cliff End, where the work is wholly of brick, the outer walls of these are built of Purbeck stone.

French.

4. At Cherbourg (Figs. 1–3, Plate II.) the casemated works are constructed of rubble walls built in horizontal beds, with a stone of laminated structure, and faced with granite.

Russian.

5. At Cronstadt (Fig. 4, Plate II.) the exterior walls are, it is believed, chiefly of granite, and with smaller embrasures than those at Portsmouth and Cherbourg.

At Sebastopol (Fig. 5, Plate II.), Fort Nicholas and the other works were constructed of magnesian limestone (*Pierre des Steppes*), the front walls having facings of coursed work, with rubble backings, not of a very sound description.

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* Plates I. II. IV. face p. 88.

American.

6. Most of the earlier American casemated works are constructed of stone (not granite), with embrasures of brick. The casemates at Fort Warren and Fort Independence, Boston; at Fort Lafayette and Fort Hamilton, New York (Fig. 6, Plate I.), are of this construction. In some instances, as in Fort Adams, Newport Harbour, they are constructed with two embrasures of this sort in one casemate.

Where stone was not easily procurable, the American works were built wholly of brick, as in the case of Fort Pulaski, Savannah, and Fort Sumter, Charleston. (Fig. 5, Plate I.).

Latest American construction of casemates.

7. During the last few years, the Americans have taken a step in advance, and in *recent* casemated Forts at the chief ports on the American coasts, they are constructed of two, three, and four tiers in height, with the front walls wholly of granite, and small pieces of iron, 8 inches thick, built in on either side of the embrasures. (Fig. 7, Plate II.).

Of this construction are Fort Georges, Portland; Fort Richmond, Fort Wilkins and Sandyhook Fort, New York; and a fort on the Rip Raps, opposite Fortress Monroe, at the mouth of the James River. Some of these works are not yet completed.

Late Russian.

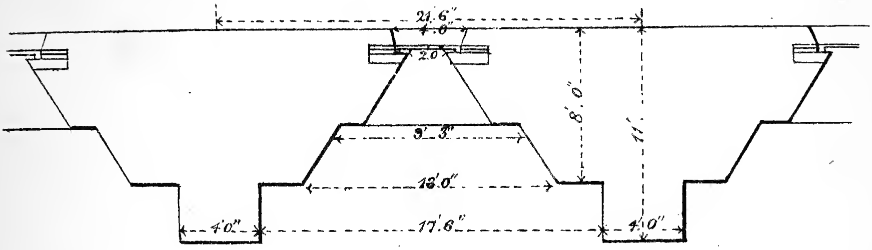
8. Up to the present time, the Russians have probably done more than any other country in the actual adoption of iron in sea defences. They have lately strengthened several of the *embrasures* of their casemated forts at Cronstadt with iron, and have also re-modeled one or two of their open batteries for the reception of iron shields. They only allow about 14 feet, however, between the guns behind these shields, whilst nearly double that distance is considered by us to be requisite for the effective working of great guns. The Russian batteries cannot be compared to ours either in space or in appliances to enable the artillerymen to work their guns with good effect.

Late English construction.

9. Even with the addition of iron such as the Americans introduced at the throats of their embrasures, the casemates above referred to could not afford adequate protection to guns and gunners against the fire of powerful rifled ordnance. This was anticipated in the designs prepared in 1861 for the casemates in the English sea defences (Fig. 8, Plate II.), which provided for greatly increasing the dimensions and strength of the mass of the masonry of the work, and for omitting the masonry round the embrasures, where, owing to the necessity of having sufficient space for the working of the guns, it was weak. Openings have thus been left for iron shields, and the construction has been arranged so that the iron (which was not provided for in the original estimates for the works) may be inserted in the openings at any time when funds are available for the purpose. We

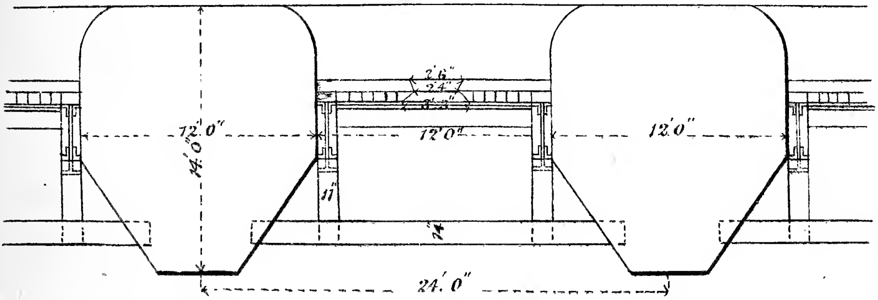
PLAN SHEWING ENGLISH & AMERICAN SYSTEMS OF CONSTRUCTION.

FIG. I.



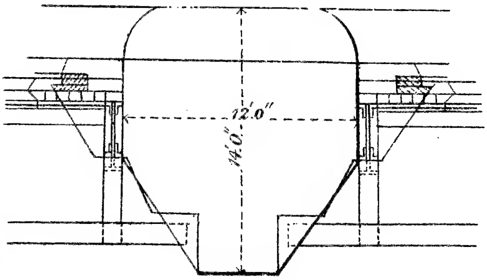
AMERICAN EMBRAZURE

FIG. II.



ENGLISH EMBRAZURE

FIG. III.



SKETCH SHEWING COMPARISON

Scale 10 Feet to 1 Inch.

have in this manner been enabled to proceed with our sea defences without increasing the total estimates for fortifications included in the Schedule of the Fortification Act. Independently, moreover, of the necessity of deferring the provision of iron shields until funds are available for the purpose, it has been desirable to do so, pending the settlement of Artillery questions by which the amount of strength necessary to be given to the shields, could be more positively defined, and the dimensions and precise position of the embrasures in the shields, could be finally decided with reference to muzzle-pivoting carriages.

Besides increasing the thickness of the exposed masonry and substituting iron for granite in the space immediately about the guns, the arches of the casemates have been constructed so as to make the whole roof afford support to that part of the masonry above the shields and piers. (See Figs. 3 and 4, Plate IV.).

Figs. 1—3, Plate III. show the mode of construction thus described, as compared with the recent American casemated sea defences, and which, as before stated, are the most approved of the previous construction.

Experimental casemates, and objects of experiment.

10. With a view of ascertaining the quantity and weight of fire from heavy rifled artillery which must actually take effect upon any one portion of a casemated battery of the late English construction to render that portion no longer tenable by its defenders, two casemates were erected at Shoeburyness in 1864–5.

There were also other objects attained by the experiment, viz.:—

(1) Some improvements in the detail of construction, in order to afford greater resisting power at trifling additional cost, were suggested by the experiment.

(2) The trial showed, contrary to expectation, that a brick arch, representing the intermediate floor of a casemate, of 20 feet span and only 18 inches thick, with a layer of concrete over it only 6 inches thick at the crown, was amply strong enough as a platform from which to fire shot or shell with full charges from a 600-pr. gun.

(3) The experiment further showed that the casemates were admirably adapted for the working of 12-ton guns, or even larger guns if thought desirable, and valuable information was obtained as to the appliances necessary for working great rifled guns in casemates.

(4) Two different kinds of iron embrasure shields were tried, one 12 feet long by about 8 feet high, arranged so that it could be put into its place at any time after the completion of the masonry, on the plan adopted in our sea defences; the other 6 feet by 6 feet, and built into the work.

(5) The amount of battering which each of these shields would resist, and the relative advantages of each were ascertained.

Main object of experiment.

11. It formed no part of the design of the proposers of the experiment, however, to make a comparison (as supposed by the Ordnance Select Committee) between a granite structure with iron shields at the embrasures and a structure wholly plated with iron. It was known before the experiment was proposed that a granite, or indeed any other structure, could be destroyed if fired at leisurely and by sufficiently powerful artillery from a land battery for a sufficient length of time. It was of course also known that an iron structure could be made stronger than a granite structure, if expense were no object.

The main object of the experiment was to ascertain the power of resistance of a granite casemated fort to a sea attack.

Effect produced not so great as was anticipated.

12. The granite outside was, of course, much smashed by the successive shots and salvoes fired at it; but in the interior of the casemates, there was for a long time no effect produced which would have prevented the guns being worked. The result, indeed, showed a much greater stability under a close and deliberate fire of modern ordnance than had been expected.

This is evident on a comparison of the reports of the Ordnance Select Committee, dated respectively the 26th May, 1865, and the 12th December, 1865.

In the first report, dated 26th May, 1865, the Committee stated that a casemate of the description referred to "*would be rendered untenable if struck by half a dozen consecutive shots delivered from a gun of equal power*," *i.e.* a 12 ton gun. In the second report, dated 12th December, 1865, the Committee state that the casemates "were noted as *beginning to be untenable after the 33rd hit on the granite*, and quite so after the 54th hit."

13. The details of the experiment, which will be found more at length in the report of the Ordance Select Committee were as follows :—

The structure experimented upon is shewn in Figs. 1-4, Plate IV.

The superficial area of the part fired at was about 630 square feet; the area of the granite fired at was about 520 square feet, and that of the iron shields (after deducting the space occupied by the embrasures) about 110 square feet.

The guns, projectiles, and charges used in the experiment were as follows:—

Calibre.	Weight.			Charge.		Weight of shot.	Striking velocity.	
				600 yds.	1000 yds.		600 yds.	1000 yds.
in.	tons.	cwt.	lbs.	lbs.	lbs.	lbs.	ft.	ft.
10·00	12	2	57	41·3	36·00	280	1273	1209
9·22	12	2	56	39·5	30·25	220	1395	1322
8·00	6	19	50	26·0	22·00	150	1369	1292
7·00	6	19	72	18·0	...	115	1370	

The battery was placed at 200 yds. from the casemates, but the charges were reduced so as to represent the striking velocity at 600 and 1000 yds. range with full service charges.

Eighty-seven shots were fired at and hit the structure; of these, 65 (16 being in four salvoes of four guns each) hit the granite, and 22 (all in single shots) hit the iron; *i.e.* one shot for about every 8 ft. of granite fired at; one shot for about every 5 ft. of iron; and one shot for about every 7·3 ft. over the whole.

Of the 65 shots at the granite, 12 shots (8 of them being in two salvoes of four guns each) were fired at the arch over the large shield, 10 were fired at the arch over the small shield, 11 at the pier on right of large shield, 10 at the pier on left of small shield, and 21 (8 of which were in two salvoes of four guns each) at the space between the two shields.

After 87 blows, including the 22 upon the iron, the face of the work was destroyed.

It does not appear, from experiment, that granite should not be used in face of casemates.

14. It is assumed by some that the result of this experiment shows that granite should not be used in those parts of a casemated work which would be exposed to fire. It is submitted, however, that this view is fallacious. The most important point to be taken into consideration in order to form a just conclusion on the subject is, what portion of the amount of fire which destroyed the fronts of the two experimental casemates would have taken effect upon them, supposing them to form part of a fort attacked by a naval squadron?

It should be observed that the conditions under which the experimental casemates were fired at were very different from those which would exist in the case of a naval attack upon a fort. Although in the experiment the charges were reduced to represent ranges of 600 or 1000 yds. the actual range and the measure of accuracy was 200 yds. The casemates were, moreover, fired at leisurely from a land battery with a perfectly steady platform; every shot was aimed, sometimes four shots together were directed, at a particular spot with the most perfect accuracy, and the fire of the guns was not returned by artillery from the fort. The fire from a ship, more especially during action and in a cloud of smoke, cannot of course be directed with that precision which can be obtained from a land battery. There will, consequently, be a great chance against several successive shots from ships striking the same spot in the fort; moreover, the fire of the ship is, with the ship itself, liable to be disposed of by a few, perhaps one or two, well-directed shots from the fixed and steady platform of the fort, and it is, therefore, improbable that vessels could remain in action long enough to do any effectual damage to it. It must further be borne in mind that usually the fort would consist of a series of casemates mounting 20, 30, 40, 50, or more guns, and that there would be more than one fort bearing upon the attacking ships.

Cases of naval attack on forts.

15. The only cases in which I have been able to obtain data of the effect of the fire of ships upon forts are those of the naval attack upon the forts at Sebastopol in 1854, and upon Fort Sumter in April, 1863. In the former case, it is true, the guns employed were very inferior to those now in use; but the masonry of the forts was also weaker in nearly the same proportion. In the latter case the conditions were reversed. Guns of the largest calibre were brought against a work designed to resist only the old class of ordnance.

Naval attack on Sebastopol.

16. In the naval attack on Sebastopol the allied fleet consisted of 27 ships, viz. 11 English, 14 French, and 2 Turkish, mounting in all 2488 guns. Half this number 1244, were engaged. The French state that 30,000 rounds were fired, but Todleben, who calculates the number of rounds fired at 50,000, considers that the French account only refers to the fire of the French fleet.

Five Russian works, two of which were casemated, took part in the defence, viz. as follows.

Work.	Armament*
Fort Quarantine (open battery)	48 guns.
Fort Alexander (partly casemated)	51 〃
Fort Constantine (casemated, with guns in open battery on terreplein)	43 〃
Wasp Redoubt	5 〃
Telegraph Battery	5 〃

The French and English fleets opened fire at ranges varying from 1000 yds. to 1900 yds., the English being on the left and nearest the batteries to which they were opposed, viz. Fort Constantine, the Wasp Battery, and the Telegraph Battery.

The engagements lasted about four hours, and the allied fleet was obliged to haul off with a large number of its ships seriously disabled.

The only damage done to the Russian works by the fire of the fleet, was as follows :—

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* The English account states the number of guns in these works to be as follows, viz. :—

	guns.		guns.
Fort Quarantine	51	Fort Constantine	104
Fort Alexander	64	Wasp Redoubt	12

Telegraph Battery, 17 guns.

This number must, however, refer in each case to the whole work, whereas the Russian account refers only to that part of the work which was engaged.

Work.	Damage.
Fort Quarantine	3 guns in *open* battery dismounted, and 7 carriages disabled.
Fort Alexander.........	3 guns in *open* battery dismounted, and 3 carriages disabled.
Fort Constantine	22 guns, *all on terreplein*, dismounted. Casemated guns not touched. The cheeks of 10 embrasures damaged.
Wasp Redoubt,.........	Nil.
Telegraph Battery, ...	1 carriage disabled.

In these works, therefore, the only effect produced by 1244 guns, firing 30,000 to 50,000 rounds, was the dismounting of 28 guns and the disabling of 11 carriages (all in open batteries).

Of all the works, Constantine, a casemated battery built of masonry of a rather inferior character, was exposed to the most severe fire, being enfiladed and taken in reverse by a part of the English fleet. But although the outer wall was covered with hits, in no case was it penetrated, and not a gun in the casemates was dismounted.*

Naval attack on Fort Sumter.

17. As regards the naval attack upon Fort Sumter; in the official report of the action by the Engineers of the Confederate Army at Charleston, there is a detailed record of the effect of the firing upon the fort. I have a copy of this report, an abstract of which is given in the accompanying memorandum A, pp. 87, 88.

The attacking force consisted of eight turreted ships (Monitors), one with two the rest with one turret, and the "Ironsides," an iron-plated ship of 16 guns. The guns in the ship were 15-inch and 11-inch ordnance.

The ranges at which they fired were from 900† to 1500 yds. from the fort.

Fort Sumter was built entirely of brickwork, only 5 ft. thick about the embrasures, and at no part more than 11 ft. thick.

The armament mounted on the faces of the fort exposed to attack was as follows:—

4	10-in.	2	7-in. rifled.
2	9-in.	6	42-prs. rifled.
8	8-in.	8	32-prs.

3 ... 10-in. mortars.

The engagement lasted 2½ hours, the vessels delivering their fire deliberately and successively, somewhat in the manner that our squadron proceeded

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* This detail is taken from Todleben's account, but it agrees with the opinion formed by English officers who visited the work after the taking of Sebastopol.

† Federal accounts state that their vessels approached much nearer to Fort Sumter than 900 yards; but General Ripley, who was in immediate charge of the defence at Charleston at the time of the naval attack, says this was not the case.

in the attack upon Odessa in 1854. The "Ironsides" was obliged to retire in 45 minutes, and the "Keokuk," a two-turreted Monitor, was sunk by a 117 lb. shot from a 7-in. rifled gun 1 hour and 40 minutes after the commencement of the action.

The area of that part of the work exposed to the fire of the ships, was 8000 square feet.

It appears that out of about 83 shots fired at the fort, at an average range of about 1200 yds., 58 struck; and that in only one case did three shots strike near the same point. Fort Sumter was, however, quite serviceable at the end of the naval action. It was, subsequently destroyed by a long continued fire from land batteries, it not having been constructed to resist an attack by artillery on the land side.

18. Applying the experience gained at Fort Sumter to the experiments at Shoeburyness, we find that the proportionate area of the part of the two experimental casemates fired at (viz. about 640 ft. superficial), being about $\frac{1}{12}$th of that of the portion of Fort Sumter fired at,—and the proportion of shot which hit Fort Sumter, being at most $\frac{3}{4}$ths of the number of shots fired at it,—the number of shot that would probably have hit the two casemates experimented upon at Shoeburyness during a naval attack upon a fort of 24 casemates, constructed on the granite and iron plan, would have been $\frac{3}{4}$ of $\frac{87}{12} = 5{\cdot}5$ shots nearly,* instead of 87; that is to say, it would require 16 times the accuracy and concentration of fire that was attained by the iron-clad fleet against Fort Sumter, to produce the result which occurred in the experiments at Shoeburyness, viz. the destruction of the fronts of two casemates.

It must be remembered, moreover, that the assailing fleet would not only be opposed by the fire from casemated works, but that powerful open batteries and guns in turrets (for the reception of which provision will be made in some forts), submarine mines, floating obstructions, and moveable floating batteries, would also be employed in aid of the defence.

19. It cannot of course be disputed that works wholly plated with iron of sufficient thickness will afford superior powers of resistance to granite works provided with iron shields at the embrasures; but it is maintained that, in many if not in most cases, the latter construction is strong enough for its purpose.

The works constructed in England on this principle are far superior in strength to the casemated forts of any other nation, and except in cases where a work is entirely isolated, and from its position specially liable to a concentrated fire, or where the nature of the foundations may render an iron

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* Accounts from Federal sources state that 135 rounds were fired at the Fort by the Monitors and "Ironsides." If this be the case (and the attacking party should be the best judges of the number of shots they fire), the proportion of hits would be much smaller than I have here stated.

structure advisable, there are no sufficient reasons for incurring great additional expense by the *general* adoption of wholly iron-plated works.*

WAR OFFICE, Oct. 1866. W. F. DRUMMOND JERVOIS.

A.

An analysis of the Statements contained in a Confidential Report by Major D. B. Harris, C.S.A., with reference to the Bombardment of Fort Sumter, Charleston Harbour, by the Monitors and Ironsides, under the command of Admiral Dupont, on the 7th of April, 1863.

Fort Sumter was a brick casemated work, designed to mount two tiers of guns in embrasures, and one tier *en barbette;* in all, 135 guns. The upper tier of embrasures was not finished by the Federal Engineers, and was never completed by the Confederates; the spaces left for them were walled up with brickwork. At the date of the bombardment the exposed faces (viz. the eastern and the north-eastern) mounted 33 guns.

The fort was bombarded from distances varying from 900 to 15,000 yards with the following results, viz.—

DETAILED TABLE.	ft.	REMARKS.
15-inch shells—		
8 shells struck fairly; average penetration	2·40	Two of these shells "destroyed" two embrasures, two others dislocated the masonry of two piers, and knocked out the arches of the embrasures. One shell broke, and stuck in the sole of an embrasure.
1 entered W. Quarters, exploded, damaging walls.		
3 scaled, ricocheted, and spent.		
—		
12 total.		

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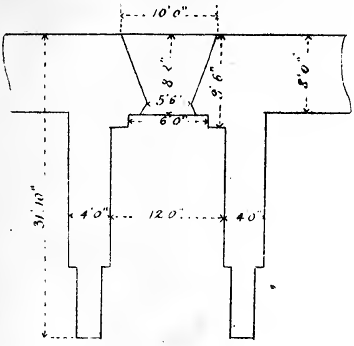
* Reports have recently reached this country of an experiment made at Fortress Monroe, in America, against a granite wall 36 ft. long, 30 ft. high, and 8 ft. thick, covered with four 1-in. plates of iron placed one upon another, and fixed by iron bolts passing through the wall. It is stated that this structure was destroyed by eleven shots from a 15-inch smooth-bore gun, and a 12-inch rifled gun, at a range of 350 yds. The experience gained in this country would lead us to have anticipated this result. The wall, only 8 ft. thick (they are 14 ft. thick in the new English works), was not supported by the arches of casemates behind it, which, in the English works, form a large portion of the strength of the structure; and the iron plating was so insufficient and so ill-arranged as to afford no appreciable aid to the resistance of the mass. If there had been a thin plate of iron at the back of the granite, in addition to the plating in front, and the whole had been supported either by arches or by struts answering the same purpose, the structure would have resisted very well.

Detailed Table.	ft.	Remarks.
11-inch shot—		
4 shots struck fairly; average penetration	2·25	One shot destroyed an embrasure; the damage caused by the remainder was inconsiderable.
1 entered W. Quarters.		
2 scaled, ricocheted and spent.		
7 total.		
Fragments of shells remaining—		
1 struck obliquely; no damage	...	No damage.
9 scaled, ricocheted and spent.		
10 total		
Various missiles—nature indistinguishable—		
20 struck fairly; average penetration...	1·65	These missiles fractured and shook the masonry to some extent, but the general effect was not very considerable.
1 knocked away, and broke in three pieces, a 6-in. iron slab, weight 6 cwt.		
1 demolished a 10-inch Columbiad carriage.		
1 struck end stone of masonry berm.		
6 ricocheted, or struck obliquely.		
29 total.		
Total number of projectiles fired at the Fort	80	
Total number of projectiles striking the Fort	58	
Proportion of the same striking effectively ...	$\frac{4}{10}$	
Proportion of ricochets and spent balls	$\frac{1}{4}$	
Proportion of cases in which two shots struck the same point.	$\frac{1}{80}$	Extent of crater 12 feet sup. Masonry cracked, exterior key-stone and interior arch of embrasure knocked out.
Proportion of cases in which three shots struck the same point.	$\frac{1}{80}$	Extent of crater 80 feet sup. Parapet wall cracked 25 feet long; serious damage.
Proportion of embrasures destroyed to those exposed	$\frac{1}{7}$	

BLOCK HOUSE FORT, COSPORT.

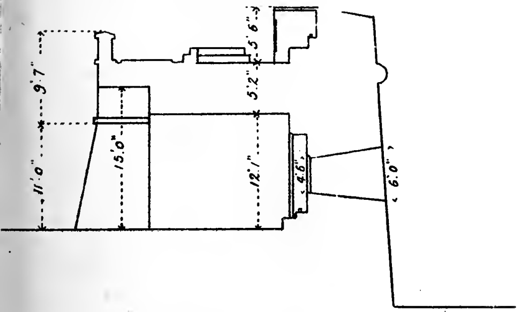
1806

FIG. I.



PLAN

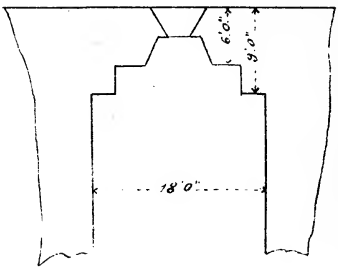
FIG. II.



TRANSVERSE SECTION OF FIG. I.

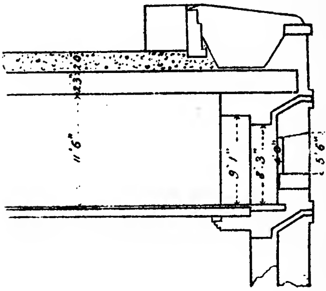
CLIFF END FORT ISLE OF WIGHT.

FIG. III.



PLAN

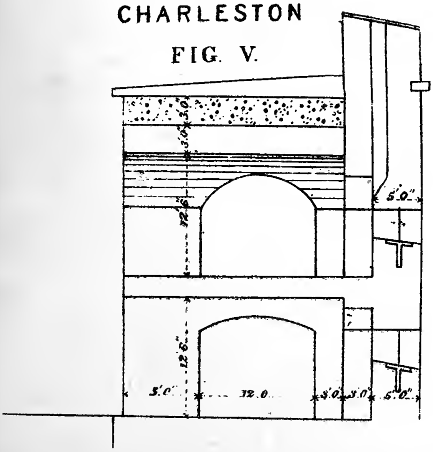
FIG. IV.



TRANSVERSE SECTION OF FIG III

FORT SUMTER CHARLESTON

FIG. V.

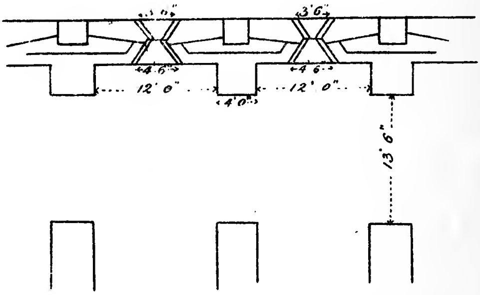


TRANSVERSE SECTION

PLAN OF EMBRASURE SAME AS FIG-6 PL. II. (IN BRICKWORK)

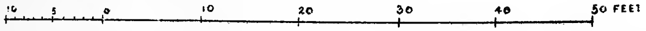
AMERICAN.

FIG. VI.



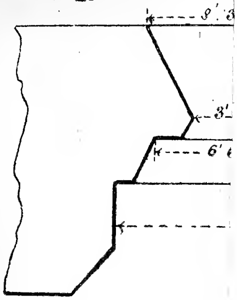
PLAN

Scale _ 20 Ft to an inch.



FOR

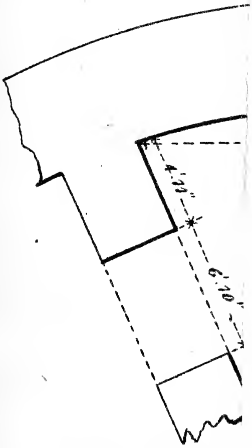
FIG I.



FORT D

C

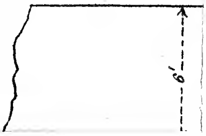
FIG. III.



FORT MICH

AT

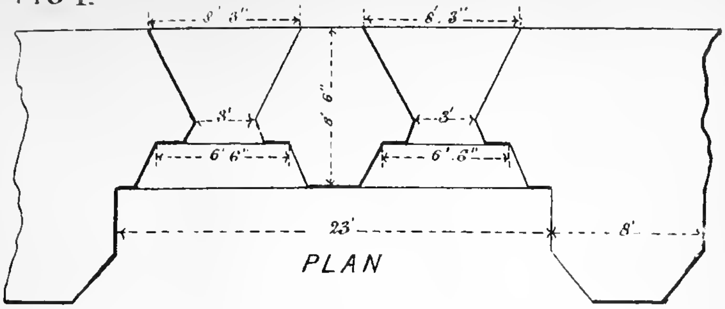
FIG. V.



PL. II

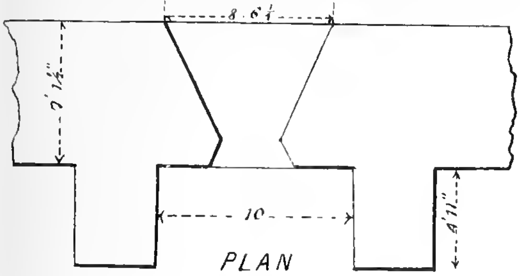
FORT DU HOMET, CHERBOURG.

FIG. I.



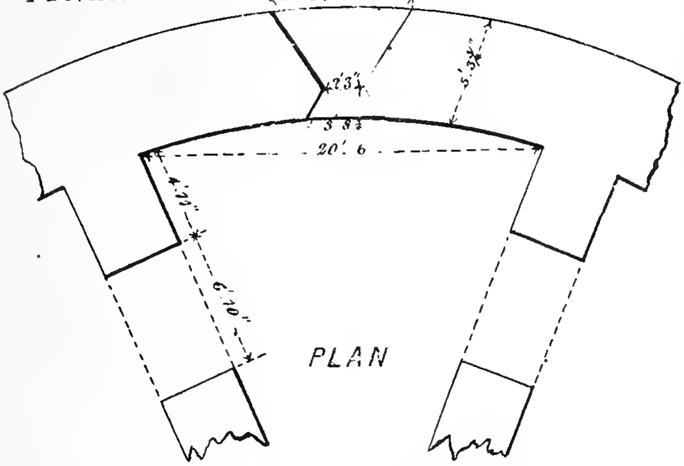
FORT DES FLAMANDS, CHERBOURG.

FIG. II.



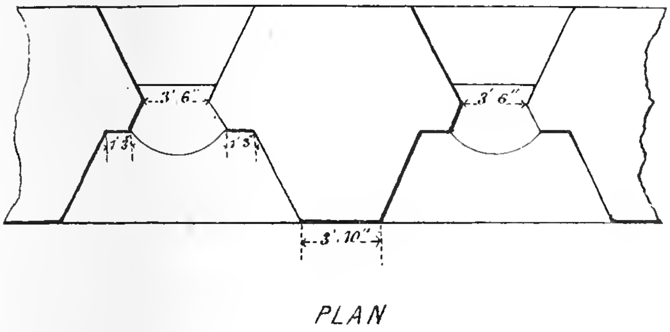
FORT DE QUERQUE-VILLE, CHERBOURG.

FIG. III.



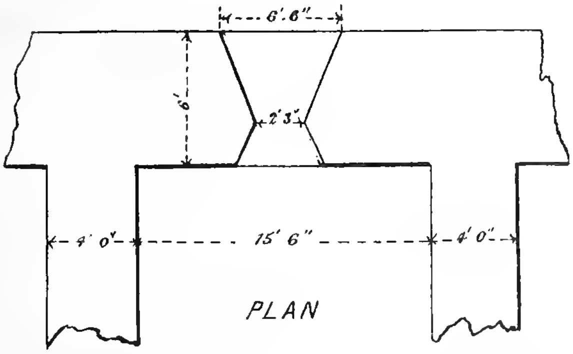
FORT MENSCHIKOFF & OTHER WORKS AT KRONSTADT

FIG. IV.



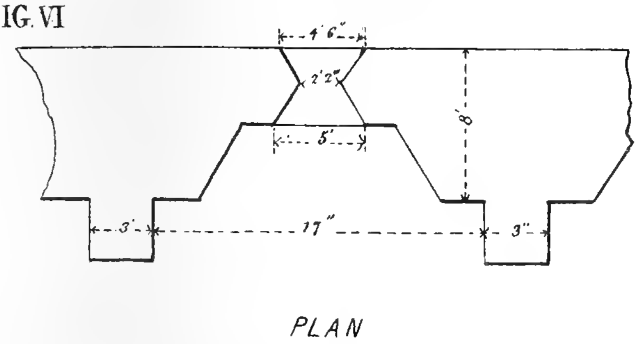
FORT MICHAEL & OTHER WORKS AT SEBASTOPOL

FIG. V.



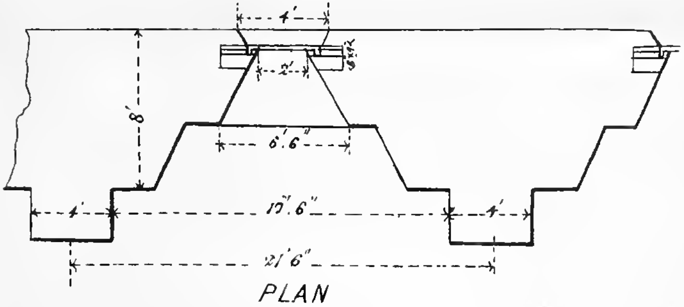
BEST FORM OF CASEMATE EMBRASURE PRIOR TO THE INTRODUCTION OF IRON

FIG. VI



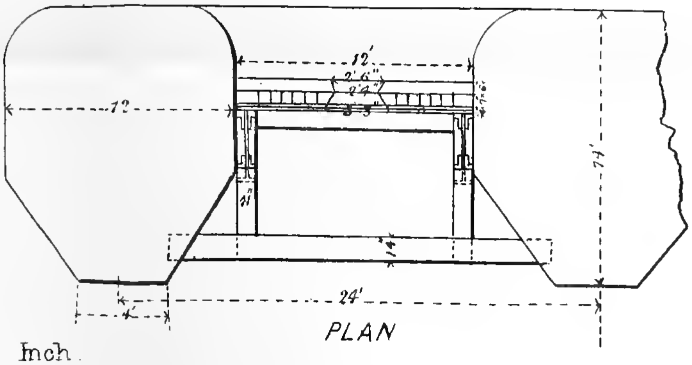
FORT RICHMOND & OTHER WORKS IN COURSE OF CONSTRUCTION AT NEW YORK.

FIG. VII.



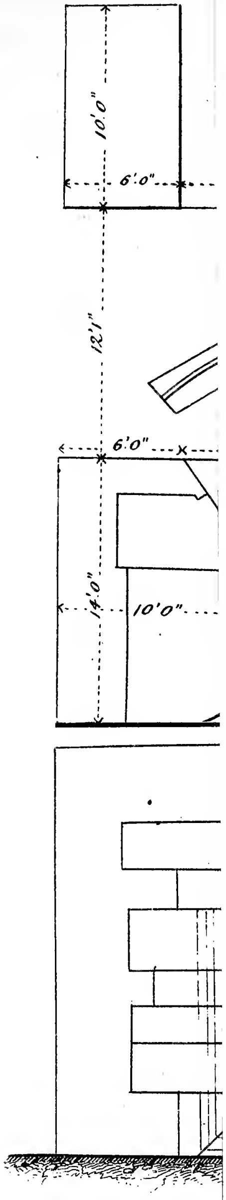
ENGLISH MODERN GRANITE CASEMATE WITH IRON SHIELD.

FIG. VIII.



Scale 10 Feet to 1 Inch.

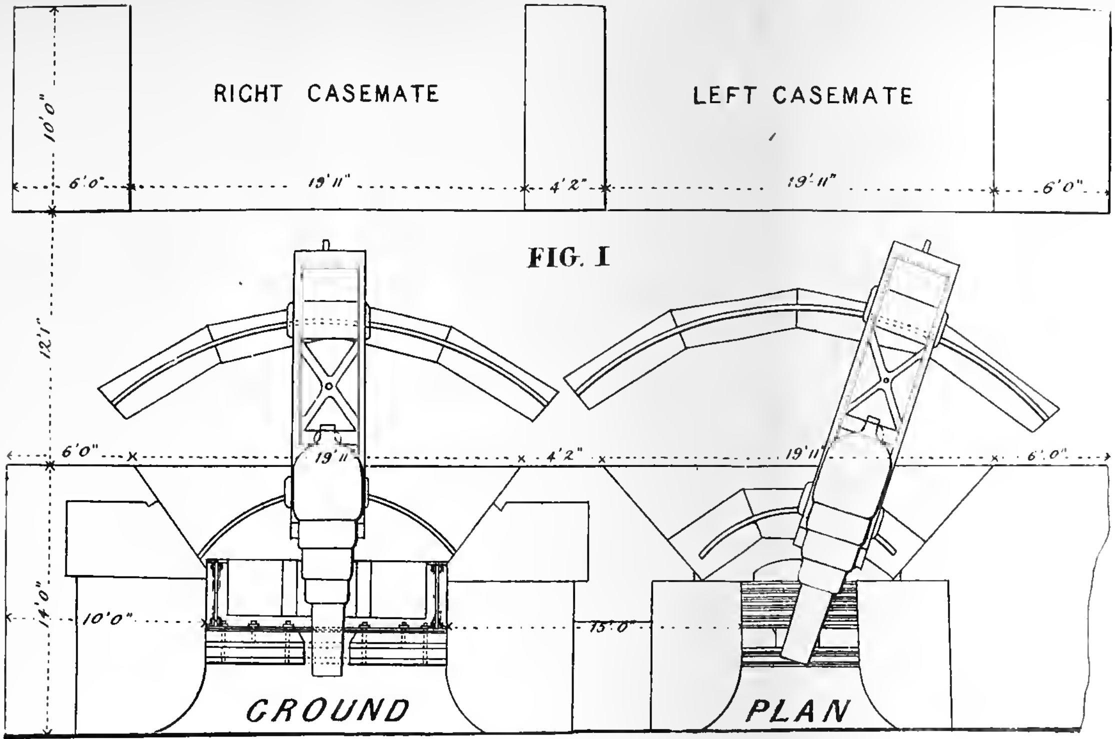
E



EXPERIMENTAL CASEMATES & WALLS,
CONSTRUCTED AT SHOEBURYNESS.

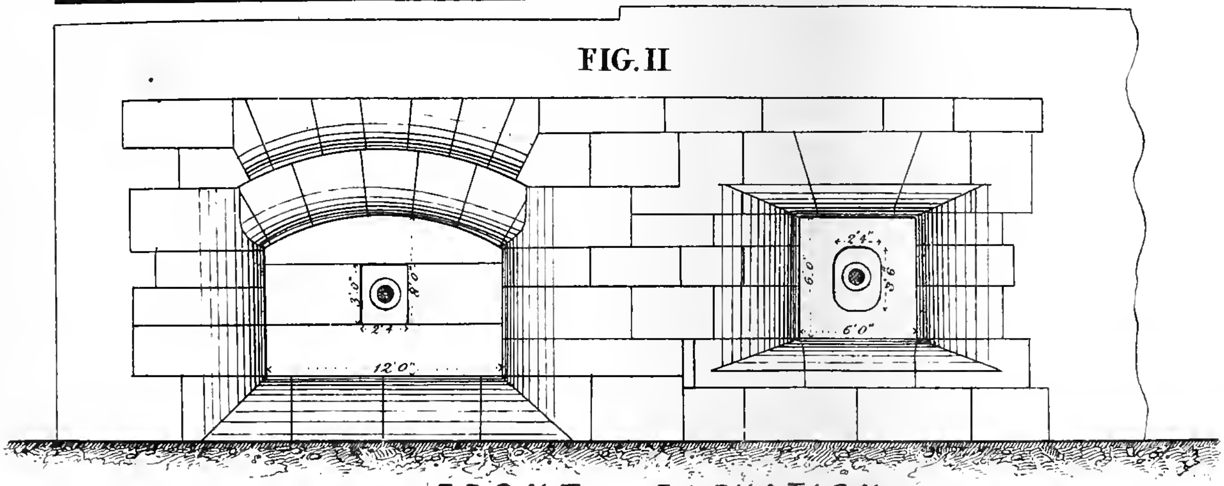
PL IV.

FIG. I



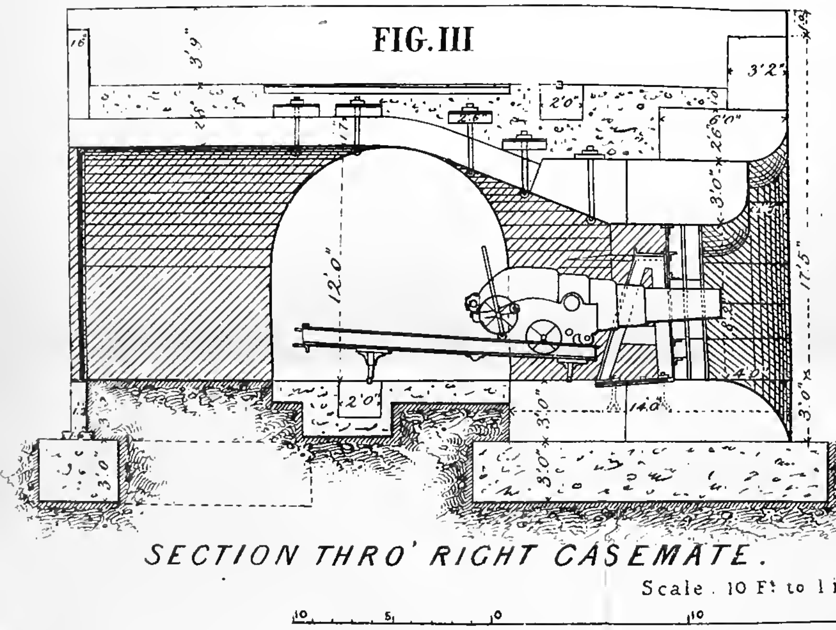
GROUND PLAN

FIG. II



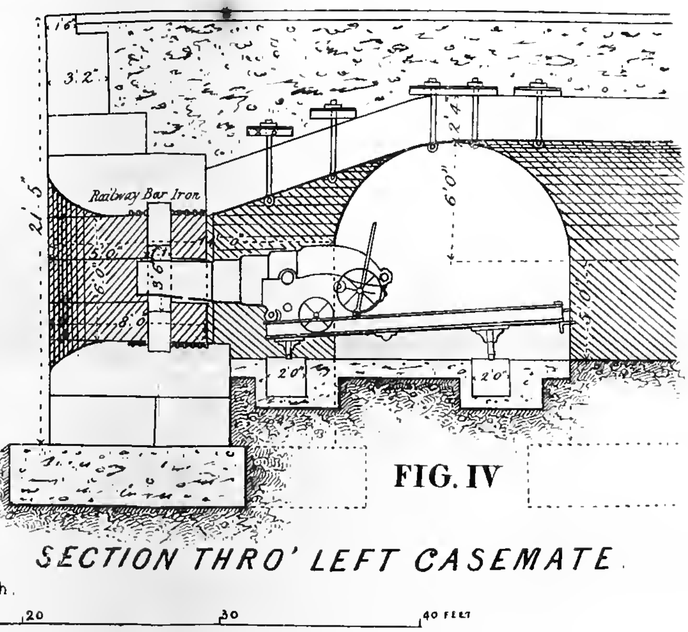
FRONT ELEVATION

FIG. III



SECTION THRO' RIGHT CASEMATE.

FIG. IV



SECTION THRO' LEFT CASEMATE.

Scale. 10 Ft to 1 inch.

10 5 0 10 20 30 40 FEET

A BRIEF HISTORICAL SKETCH
OF
OUR RIFLED ORDNANCE,
FROM
1858 TO 1868.

BY CAPTAIN F. S. STONEY, R.A.

CAPTAIN INSTRUCTOR, ROYAL GUN FACTORIES.

INTRODUCTION.

To enclose "the Iliad in a nutshell" could scarcely be a more difficult task than to compress within the limits of a serial article the history of our rifled ordnance during the last ten or twelve years—from the early Armstrong 12-pr. of 6 cwt. to the present 600-pr. of 25 tons—including the countless suggestions that have been considered and the numerous experiments that have been carried out; in short, the various steps in the tedious but enterprising march by which Artillery at length arrived at the high position it now occupies amongst the sciences. But nothing of the kind is here attempted; the following summary is simply the substance of a preliminary lecture delivered to the present "Advanced Class" of artillery officers on commencing a long course of instruction in the Royal Gun Factories, and it pretends to mark out only the main features of this extensive topic. Sources of information are, however, referred to which will enable the exploring reader to fill in the most important of the details, whilst the sketch as it is, will, it is hoped, be found sufficient for those who desire merely a general view of the subject.

Necessity for rifled ordnance.

When the Crimean war was impending, the general adoption of rifled small arms necessitated the introduction of rifled ordnance, in order that Artillery might still retain its superiority over Infantry, and remain as before, the principal arm in the field, which certainly would not be the case if an enemy's shirmishers had the power of placing a battery *hors de combat* before its too short ranged guns could be brought into action on the advancing columns.*

To supply this great want in warfare, involved a complete reformation in the architecture of Artillery, which had been almost at a stand-still since the time of the Tudors, for although modifications had been occasionally made in the manufacture of ordnance, any one who examines the old guns in the Tower of London, or in the Museum of Artillery at Woolwich, may see that they are of the same genus as modern smooth-bores, and even notice some specimens quite as soundly and as artistically cast as any of those of the present century, nay more, he may infer that our modern cast guns can scarcely be superior to their prototypes in range-power, or susceptibility to rifling.

Why rifled guns were not produced before.

It is, however, worthy of note, that this stagnation in the construction of ordnance was not to be attributed to ignorance of the theories of gunnery, but to the backward state of metallurgy and mechanism, for professional as well as amateur artillerists have even at remote periods understood the value of rifled guns, but their endeavours to obtain them were rendered abortive by the want of suitable materials and proper machinery.

The following is a list of the principal home and foreign inventors and inventions of the pre-rifle-ite period.

I have selected almost all the names of the English inventors out of nearly two hundred whose proposals are described in "MS. notes on the various designs for elongated projectiles for smooth-bore and rifled guns, which have been from time to time considered by the Ordnance Select Committee down to 1858," compiled from the records of the Committee by Lieut.-Col. (now Major-General) A. G. Burrows, Royal Artillery.

For the foreign inventors I am indebted principally to a paper by Captain R. A. Scott, Royal Navy, published in 21st number of Vol. VI. "Journal of the Royal United Service Institution":—

In the Arsenal of St Petersburg is a gun 2¾ ins. in diameter and 62 ins. in length of bore, which was rifled in nine grooves in 1615.

In 1661 the Prussians experimented at Berlin with a gun rifled in thirteen shallow grooves.

In 1696 the elliptical bore was known and had been tried in various parts of Germany.

In 1745, the date at which Robins was experimenting in England, the Swiss already possessed small rifled pieces.

1746. Munich had a rifled breech-loader made, and T. Senner was engaged in rifling various guns.

1776. Dr Pollok proposed elongated shot for smooth-bore pieces.

1790. Mr Wiggin made designs of a rifled gun and belted projectiles.

1803–1806. Proposals by Messrs Davies, Barlow, Spencer, Eckhart, &c. were considered by the O.S.C.

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* At an experiment which took place at Hythe in 1857, thirty infantry soldiers armed with Enfield rifles, picked off in three minutes the men and horses of a dummy gun detachment 800 yards distant.

1816 to 1819. M. Ponchara, a distinguished French Artillery Officer, was making various experiments with an old gun which he had rifled with thirteen grooves.

1821. Lieut. Croly, h.p. 81st Regiment, proposed *breech-loading cannon and lead-coated projectiles.*

1823–32. *Lieut. Norton* proposed explosive shells, and a rifled gun.

1826. Experiments were made with some cylindro-conical percussion shells, designed by Lieut.-Col. Miller, of the Rifle Brigade.

1833. Montigny of Brussels invented a breech-loading rifled piece.

1842. *Colonel Treuille de Beaulieu* first presented to the French Government his plan for rifling muzzle-loading guns, with a few large grooves for studded projectiles, which was afterwards adopted in a modified form, and is now known as the French system.

1845. *Major Cavalli*, a Sardinian officer, invented a breech-loader (submitted to O.S.C. 1850), rifled with *two* grooves for a ribbed shot; his guns were used at the Siege of Gaeta in 1860.

1846. The Swedish *Baron Wahrendorf* proposed the system of using lead-coated prcjectiles with shallow grooved breech-loaders. He also tried the Cavalli projectile, and rifling with guns closed at the breech on his own plan, whilst Lieut. Engstroem of the Swedish Navy affixed hard wood bearings or buttons to an iron projectile. Wahrendorf's and Engstroem's designs were submitted to the O.S.C. in 1855.

1852. H.R.H. Prince Albert proposed a concussion shell, Lord Clarence Paget a rifled projectile, Lieut.-Colonel Stevens, R.M.A., a plan for rifling 13-in. sea service mortars; Mr Mallet an improved form for rifling cannon shot and shell.

Proposals were submitted to the O.S.C. in 1853 by Lieut.-Col. Grant, Captain Norton, Captain Jodrell Leigh, Signor Verga, &c., &c., &c.

In 1854, by Major Parlby, *Mr Lancaster*, Admiral Duff, Qr.-Master Serjt. Macbay, R.A., Major Parsons, Major the Hon. W. Fitzmaurice, Major Vandeleur, R.A., Lord W. Fitzroy, Mr G. Nasmyth, Captain Anson, R.A., *Mr Hadden*, Mr (now Sir W.) ARMSTRONG, &c., &c., &c.

1855. *Capt. Blakeley*, R.A., patented his method of forming guns with an internal tube of cast-iron or steel heated and shrunk upon the cylinder, and Sir J. Woodford, Capt. Fowke, R.E.; Messrs Goddard, *B. Britten*, Underwood, Skelton, &c., and the Revs. J. Bramball and R. Potter, brought forward various designs.

1856. General Timmerhans of the Belgian artillery invented a wad which by taking the rifle grooves gave rotation to the elongated shot.

1857. Messrs J. WHITWORTH and *Mr A. Jeffery* submitted their inventions.

In short, it appears from the records of the Ordnance Select Committee that up to 1855 experiments had been made with rifled guns and projectiles for half a century in this country, but without any satisfactory result. The projectiles tried were very numerous. They were generally fired from special cast-iron 9-prs. rifled with four grooves, making a quarter turn in the bore. Specimens of those experimental projectiles are preserved in the O.S.C. Museum, Royal Arsenal; officers desirous of "inventing" a *new* shot or shell are recommended to examine previously this heterogeneous collection.

Such being the state of the case it was indeed fortunate for the ascendancy of artillery that, owing doubtless to the spread of railways, suspension bridges, &c. &c., the requisite improvement in metallurgy and in mechanical appliances should have opportunely taken place in recent years. It is only of late that the manufacture of cast steel as a material for rifled ordnance has made rapid progress, whilst the difficulties which used to attend the forging of wrought-iron in large masses were so great that a heavy anchor* was one of the greatest achievements of the forge-master until the comparatively recent introduction of steam hammers enabled him to forge our modern monster guns, and, thanks to the able mechanicians of the day, we have now rifling machines so perfect and easily manipulated that the operator could if he pleased engrave his name in the bore of a gun, and withal so accurate is their action that they work "true" to less than $\frac{1}{1000}$th of an inch, a dimension which can now be very easily measured by means of a Whitworth's micrometer, but which is fifty times too minute to be ascertained by the primitive measuring instruments of the last generation of mechanics.

A greater strain on a rifled gun than on a smooth-bore.

And here it is advisible to glance rapidly at the necessity for making rifled guns of a stronger material than smooth bores, as well as at the metals which appeared suitable for the purpose, so far as we are at present acquainted with their peculiarities.

The greater the weight and the length of a projectile, the greater is the opposition from inertia and friction which it offers in the bore to the expansion of the ignited charge, and this opposition is considerably augmented if the projectile is constrained to travel through the bore in a spiral course, hence it is not difficult to comprehend why a rifled gun must needs be of a stronger, tougher, and more elastic material than a smooth-bore gun, in which the round shot yields promptly to the first impulses of the powder gas, to which it presents half its surface, and bounds nimbly forward through the bore almost unimpeded by friction, while the strain on the gun is immensely relieved by the comparatively great windage. Again, as the explosive power of a cartridge as well as the inertia and friction of a projectile increase with their respective weights in a cubical ratio, whilst the surface of the chamber and the base of the projectile, against which the powder-gas acts, increase only in a square ratio, it follows that the weightier the projectile the harder and stronger must be the inner barrel, or else the slower must be the combustibility of the powder used; hence although any of the ordinary materials may suffice for a small gun, (the schoolboy fires a grain of grouse shot from a goose quill), large ones must be "made of

---

* This extract from Ferguson's spirited ballad, "The Forging of the Anchor," shows in what repute such an operation was held, whilst the first part of the quotation is admirably applicable to the much larger forgings which are every day to be seen in the Royal Gun Factories.

* * * O Vulcan, what a glow!
'Tis blinding white, 'tis blasting bright, the high sun shines not so;
The high sun sees not on the earth such fiery, fearful show,
The roof ribs swarth, the candent hearth, the ruddy lurid row
Of smiths that stand, an ardent band, like men before the foe;
As quivering through his fleece of flame the sailing monster slow,
Sinks on the anvil * * *

* * * * *

Swing in your strokes, in order let foot and hand keep time;
Your blows make music sweeter far than any steeple's chime;
But while you sling your sledges, sing and let the burthen be,
The Anchor is the Anvil King, and royal craftsmen we.

sterner stuff," for instance our B.L. guns are all of wrought-iron, but we line our heavier Woolwich guns with toughened steel, and if we make rifled 1000-prs. we shall have to insert a platinum chamber or, which is much more feasible, use "pellet" powder.

Materials for rifled ordnance.

Economy limits our considerations of the metals as materials for rifled ordnance to bronze, wrought-iron, cast-iron, and steel.

Bronze has several of the properties which are valuable in a gun material, but its liability to become hot and soft by repeated firing makes it still more objectionable for rifled guns than for smooth-bores, as the edges of the grooves would soon be worn away by abrasion from the studs. Bronze, however, answers pretty well for small guns, and we have made a battery or two of bronze rifled mountain guns, and a couple of field guns have been made for experiment.

The Austrians made some mountain guns of sterro-metal, which is an alloy of copper and zinc with small quantities of iron and tin added. This metal was tested in the Arsenal in 1863. It was proved to possess great strength, elasticity, and hardness, but to be more brittle and more subject to corrosion than gun-metal.*

Cast-iron is the first result of extracting iron from the ore. It therefore contains many foreign elements, the principal of which are carbon and sulphur with which it is infected by the fuel with which it is smelted, and phosphorus, silicon, and manganese, which it generally inherits from its mother earth.

Cast-iron contains from 2 to 5 per cent by weight of carbon, existing in two forms chemically combined, and mechanically combined. It is carbon in the latter state, or graphite, which gives the iron its grey or mottled appearance whilst iron with which all the carbon is chemically combined is called white iron or bright iron.

The whiter the iron the harder it is, the greyer the more tenacious. Hence mottled iron is the most suitable for guns and white iron for projectiles intended to pierce armour plates. Chilled iron is white iron artificially produced by cooling the molten metal so rapidly in iron moulds that graphite has no time to form.

·5 per cent by weight of phosphorus makes iron brittle, when cold ("cold short"), whilst a much smaller proportion of sulphur renders it brittle when hot ("red short").

Hence it is that cast-iron, possessing so many impurities in different degrees, is weak and brittle and, at all events, uncertain in its nature, and therefore not trustworthy as a wholesale material for rifled guns.

Wrought-iron and steel are simply cast-iron purified (by the processes of refining, puddling, &c.) from almost the whole of the foreign elements except carbon and perhaps a little sulphur and phosphorus, but it is carbon which is the essential difference between cast-iron, wrought-iron, and steel.

---

* Extracts from O.S. Committee Proceedings, Vol. I. p. 210.

The proportion in each is as follows:—

Wrought-iron............	·1 to ·3	per cent by weight.
Steel	·3 to 2	" "
Cast-iron	2 to 5	" "

Carbon imparts hardness and fusibility, but it has the baneful effect of making the material brittle.

If we apply a weight of 4 tons to a bar of cast-iron one inch in section, the bar will stretch to a certain extent, and on the weight being removed will return to its original length. This weight is called "the limit of elasticity," for did we apply a greater weight the bar would be permanently elongated; and when we reached about 10 tons, fracture would take place. Hence the latter is called "the breaking weight."

The limits of elasticity and the breaking weights differ with the quality of the iron, but the following table gives the average of good specimens tested by the machine in the Royal Gun Factories.

Material.	Limits of elasticity per sq. inch.	Breaking weight per sq. inch.
Wrought-iron (in the direction of its fibre)	12 tons	25 tons.
Cast-iron	4 "	10 "
Steel	13 "	31 "
Steel toughened in oil	30 "	45 "

(Wrought-iron across its fibre is only about as strong as cast-iron).

It will be seen from this table that steel, especially when toughened in oil, is the toughest, most elastic, and strongest of the iron family, but though it bears so well a gradual pressure such as the machine exerts on it, it has the glass-like defect of brittleness when exposed to a violent and sudden blow, such as the explosion of gun-cotton or even that of gunpowder. Hence a large steel gun, unless very carefully manufactured, may burst at any time, and when it does so, the fragments will be dangerously numerous; whereas wrought-iron, especially when coiled, will not burst explosively under ordinary circumstances; on the other hand, steel is much harder than wrought-iron, and thus a steel barrel is better able to resist abrasion from the studs of the projectile than is a wrought-iron barrel, and steel can also be made free from flaws and defects which is more than can be predicted of wrought-iron.

Improvements are taking place every day in the manufacture of steel, and it is now adopted altogether for the barrels of our muzzle-loading rifled guns, whilst wrought-iron coiled is used for the exterior parts, as its fibrous and pliant nature counteracts the explosive tendency of the steel.

By heating steel to a high temperature and plunging it into water (even into boiling water) we harden it very much by the rapidity with which it is cooled, but the sudden action makes it brittle and snappish. Oil is however, as a liquid, a very bad conductor of heat. It does not boil under 600 F. Hot steel, therefore, when plunged into oil parts with its heat slowly and is toughened as well as hardened.

Although gun steel—by that I mean cast-steel subsequently densified by forging, such as Krupp uses for his guns and we for inner barrels—is four or five times as expensive as wrought-iron, a steel gun costs only about twice as much as an Armstrong gun, owing to the more expensive manufacture of the latter.

The respective cost of guns of the several materials may be roundly stated as follows :—

	£	
Cast-iron guns	21	per ton.
Armstrong, wrought-iron	100	"
" " F. (or cheap)	65	"
Steel on Krupp's or Whitworth's plan	170	"
Gun-metal...................................	190	"

Lancaster guns used in 1854.

Although a good deal is still to be learnt about gun materials, our knowledge of them has greatly increased since first the necessity for rifled ordnance arose. The tendency then was to utilize the stock in hand *faute de mieux*, and when hostilities broke out with Russia in 1854, some 8-inch and 68-pr. cast-iron guns were oval bored on Mr Lancaster's plan and sent, by way of experiment, to the Baltic and Black Sea, but they turned out a failure, as in most cases the straight sided projectile then used jammed in the spiral bore and ruptured the chase.*

French rifled field guns in the Italian campaign, 1859.

In the lull which succeeded the Crimean Campaign, Napoleon III. turned his attention to the rifled artillery problem, and came to the conclusion that the readiest mode of solving it would be to rifle his bronze field guns on Colonel Treuille de Beaulieu's plan. Thus equipped he began the Italian War of 1859, and at Magenta and Solferino he reaped all the advantages he had expected from his superior Artillery.

Steps taken by the other Continental powers.

The Austrians smarting from the painful lesson they had learnt from their adversary, made definite trials early in 1860 between B.L. guns with lead-coated projectiles, and M.L. guns rifled for studded shot on the French plan, and decided in favour of the latter system as being simpler,

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* Mr Lancaster now adapts the form of his projectile to the twist of the bore, and is obtaining promising results with a 9-in. gun. It is therefore possible that as he was the first to enter the field, he will be the last to leave it, for his system (other difficulties being overcome) is very suitable to steel barrels which are so much weakened by the *grooves* of every other system and possesses the advantage of projectiles which are without projections of any kind.

and considering its application to the existing stock of their bronze and cast-iron (when hooped) guns, generally more expedient; the Italians and Swedes who at first tried breech-loaders followed their example, as did also the Spaniards and Dutch, whilst the Russians, Prussians, and Belgians adopted breech-loaders of cast-steel manufactured by Herr Krupp of Essen.

For a detailed list however of the ordnance of Foreign powers, giving the material dimensions and systems of the several guns employed, the reader is referred to General Lefroy's "Hand-book for Field Service, 1866," pp. 329–36.

"It is to be remarked generally that no account is taken in this Table of those powerful rifled guns manufactured in this country (principally by Sir Wm Armstrong & Co., Elswick, Newcastle), which are known to have been purchased by the Governments of Turkey, Egypt, Italy, Denmark, the South American Republics, and even Japan."

The Armstrong principles of construction.

Meanwhile our own authorities carried on careful and extensive experiments with wrought-iron rifled breech-loading guns, constructed by Mr (now Sir W.) Armstrong, whose main principles of gun architecture consist essentially:—

First, In arranging the fibre of the iron in the several parts so as best to resist the strain to which they are respectively exposed; thus the walls or sides of the gun are composed of coils with the fibre running round the gun, so as to enable the gun to bear the transverse strain of the discharge without bursting, whilst the breech end is fortified against the longitudinal strain, or tendency to blow the breech out, by a solid forged breech piece with the fibre running along the gun.

Secondly, In shrinking on the successive parts together with tensions so regulated that each part shall do its due proportion of work on the discharge of the piece, thus the outer coils contribute their fair share to the strength of the gun, whereas in an ordinary homogeneous gun the inner portions receive the brunt of the explosion whilst the exterior ones are hardly affected by it at all.

By a combination of these two principles (which are applicable alike to breech-loaders and muzzle-loaders), a gun is obtained which may be calculated to be twice as strong as a gun of the same weight and shape made out of a solid forging.

The first Armstrong experiments.

Sir Wm Armstrong, whose system included a breech-loading arrangement and lead-coated projectiles, brought his guns to official notice in December, 1854, and received an order for a few for trial.

"The first of these, a 3-pr., was delivered in July, 1855, and reported on favourably by the Ordnance Select Committee, who desired to make further experiments.*

"The gun was re-bored up to a 5-pr., and in December, 1856, was tried near Newcastle in presence of Colonel Eardley-Wilmot, R.A., Superintendent Royal Gun Factories, who reported that at 1500 yards and 2000 yards the gun had made remarkably good practice."

A second gun, an 18-pr., of the same weight as the 9-pr. bronze field gun, was experimented with at Shoeburyness. This gun showed great strength, precision, and range power, and subsequent experiments with larger guns only confirmed the excellence of the system.

"At the same time extensive experiments were carried on to test whether any safe method of strengthening cast-iron guns could be found, or whether any better, speedier, or cheaper system of constructing rifled ordnance existed than that proposed by Sir Wm Armstrong. None such having been found within the period for inquiry, the Armstrong system was completely adopted;" and in order to obtain a supply of the guns and projectiles as soon as possible, so that we might not be behind other nations, Government not only entered into a contract in January, 1859,† with the newly-established Elswick Ordnance Company, but commenced their manufacture in the Royal Arsenal, Woolwich.

In February, 1859, Sir Wm Armstrong, who was connected with the Elswick firm, was appointed engineer of rifled ordnance (being knighted at the same time and created a C.B.), and in the following November he became also Superintendent R.G.F.‡

Our field artillery was soon furnished with the new guns, and a goodly number, especially of the larger natures, were at the urgent request of the Admiralty supplied to the fleet, and subsequently the whole series of Armstrong guns as given in the annexed Table, was added to our armaments.

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* This and a few of the succeeding paragraphs are abridged from the blue book, containing the Report of the Select Committee on Ordnance Expenditure, which were appointed by Government in 1862, and submitted their Report 23rd July, 1863. The members of this Committee were:—

Mr Monsell
Sir George Lewis
General Peel
Captain Jervis
Mr T. G. Baring
Sir Frederick Smith
Mr Dodson
Sir John Hay
Lord Robert Cecil
Mr Laird
Major O'Reilly
Mr Beecroft
Sir Morton Peto
Mr Vivian.

† This agreement terminated in 1863, since which time all the Government guns have been made in the Royal Gun Factories.

‡ Sir Wm. Armstrong resigned these offices on the 5th February, 1863. He was succeeded as Superintendent R.G.F. by Col. F. A. Campbell, R.A.

TABLE

SHOWING DIMENSIONS, RIFLING, SERVICE, &c. OF BREECH-LOADING ARMSTRONG GUNS.

It is probable that B.L. guns will not be made again in considerable numbers. There are none in the estimates 1868-9.

Nature, weight, and service.	Bore.		Length of gun.			Diameter.		Rifling.				Preponderance of sealed pattern.	Approximate number in the service.
	Calibre.	Length.	Over all.	From muzzle to axis of trunnion.	From axis of trunnion to breech.	Greatest over charge.	Muzzle.	System.	Twist.	Grooves.*	Width of lands.		
Breech Screw.	″	″	″	″	″	″	″				″	cwt. qrs. lbs.	
7″ of 82 cwt. L.S. &. S.S. †	7	99·5	120	74·7	45·3	27·7	13	P‡	1 in 37	N 76 D ·06 W·166	·1233	6 3 16	950
7″ of 72 cwt. L.S.	7	97·5	118	71·25	46·75	24·7	13	″	″	N 76 D ·06 W·166	·1233	7 3 27	76
40-pr. of 35 cwt. L.S. & S.S....	4·75	106·375	121	73·875	47·125	16·4	7·75	″	1 in 36½	N 56 D ·06 W·166	·1	4 3 0	750
40-pr. of 32 cwt. L.S. & S.S....	4·75	106·375	120	73·875	46·125	16·438	7·75	″	″	N 56 D ·06 W·166	·1	5 1 19	200
20-pr. of 16 cwt. L.S.	3·75	84·0	96	59·375	36·625	12·5	6·0	″	1 in 38	N 44 D ·06 W·166	·1	2 0 11	100
20-pr. of 15 cwt. S.S.	3·75	54·125	66·125	39·5	26·625	13·5	6·25	″	″	N 44 D ·06 W·166	·1	1 2 0	30
20-pr. of 13 cwt. (boat) S.S. ...	3·75	54·125	66·125	40·0	26·125	12·5	6·0	″	″	N 44 D ·06 W·166	·1	1 1 24	300
12-pr. of 8 cwt. L.S. & S.S....	3	61·375	72	38·75	33·25	9·75	5·75	″	″	N 38 D ·045 W·148	·1	1 3 3	700
9-pr. of 6 cwt. L.S. & S.S....	3	52·5	62	36·5	25·5	9·6	5·3	″	″	N 38 D ·045 W·148	·1	0 2 26	275
6-pr. of 3 cwt. L.S. & S.S....	2·5	53·0	60·125	37·0	23·125	7·0	3·75	″	1 in 30	N 32 D ·045 W·148	·1	0 1 27	100
Wedge. 64-pr. of 61 cwt. L.S.	6·4	92·0	110·0	68·5	41·5	24·2	14·1	″	1 in 40	N 70 D ·06 W·166	·1212	5 2 0	85
40-pr. of 32 cwt. S.S. §	4·75	83·5	98·0	63·8	34·2	19·2	7·75	″	1 in 36½	N 56 D ·06 W·166	·1	2 3 5	50

Royal Gun Factory,
June, 1868.

(Signed) F. A. CAMPBELL, Col. R.A.,
Superintendent, R.G.F.

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* The number, depth, and width of grooves are distinguished by letters.

† The S.S. 7″ B.L. guns will gradually be replaced by 7″ M.L. rifled guns.

‡ Polygroove.

§ Takes the 40-pr. breech-screw ammunition.

To see how these guns fulfilled the expectations of the authorities it will be sufficient to refer to the testimony of the various officers who handled them in active service.

Behaviour of the Armstrong B.L. guns on active service.

The field guns were first used in China in 1860, and Col. T. Milward, Royal Artillery, who commanded the artillery of the first division there, gives a favourable account of their efficiency*.

He states: "The guns were sent from England covered with a composition of white lead and tallow, and packed in wooden cases, out of which they were taken when we arrived at Hong Kong, and completely cleaned, and then no more composition was put on them, or cases of any kind; they were generally kept mounted in the hold of the ship, and they were embarked and disembarked in rough weather, and no damage ever received to them of any description.

"At Talienwhan we landed several of them in our ship's boats on a temporary apparatus which we put up ourselves, and in rough weather, but nothing occurred to them. On one occasion my guns had very rough work indeed; we were sent out with a division of the army over a swamp, the very worst ground possible for artillery; the guns were, in fact, almost swallowed up, but we got them through quite safely, and when we came into action we found no damage had been done; everything, including the sights, was covered with mud, but in a few minutes we cleaned that off, and the guns were just as good as ever.

"At 2000 yards, which was the greatest range we engaged at, our segment shells had great effect, whilst at 450 yards the effect was greater than from common smooth-bore case shot, but we felt much the want of a common shell with a large bursting charge. On one occasion 24 lb. howitzers set fire to junks which Armstrong guns tried to do, and failed.

"The shell acted well with concussion fuzes, but the time fuzes were bad, having been injured on the voyage out from damp. The effect of our shells against earthworks was trifling, owing to the small charge, but the segments did a great deal of damage inside the works.

"During the whole campaign we only fired an average of 200 rounds per gun.

"The vent pieces were faced once by the armourer serjeants, who effected all the necessary repairs.

"One old-pattern vent piece was blown away."

Colonel John Desborough, Royal Artillery, who commanded a division of Artillery (one Armstrong battery, and one smooth-bore battery), gives his opinion before the same Committee (p. 50), that an Armstrong battery is not as effective at short ranges as a smooth-bore battery, but that the Armstrong guns were not sufficiently tried in China to judge of their merits."

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* Armstrong and Whitworth Committee, pp. 43, 47.

Lieut.-Colonel Barry, who commanded the Armstrong battery referred to, reported that, "After having bivouacked for the night at Sangku in the rain, the breech-screws were nearly completely jammed with rust." It is to be observed that these were the old pattern breech-screws with square threads; jamming from rust could scarcely take place with the bevel-shaped thread, which has a play of ·02 of an inch.

Major R. J. Hay, R.A. Assist.-Adj.-Gen., R.A. in the same campaign, finding that his statements relative to the Armstrong gun were so twisted and distorted by opposition written in the public press, wrote 25th March 1861, to Sir Wm Armstrong, to say that "the Armstrong guns in China rendered the most valuable service, being always in the most efficient and serviceable condition, although put to very severe tests. It would have been most surprising if slight alterations had not suggested themselves in both guns and ammunition, considering that they were tried for the first time, and that they were most jealously watched by all."

Lieut. Pickard, V.C., R.H.A., who took an active part in the New Zealand campaign, 1861, 3, 4, records his opinion as follows:—

"The Armstrong field guns were always most effective where a long range or great precision was required, and they are therefore in every way an admirable substitute for, and improvement on, the old 9-pr. bronze smooth-bore guns.

"The great number of times that the Armstrongs were taken to pieces, and the continual rough usage which they met with in embarking and disembarking and in crossing rough country, without sustaining any damage, shows that they are not liable to get out of order from being of too delicate manufacture. They can be loaded and fired very quickly with time and concussion fuzes with well drilled detachments.

"But although the Armstrong field gun has been proved to be an admirable substitute for the 9-pr. smooth-bored gun, yet it can in no way replace the 24-pr. howitzers which for obvious reasons were associated with 9-pr. batteries before the introduction of rifled ordnance.

"When a moderately thick earthen field parapet requires to be breached by field guns, as at the 'gate-pah' engagement—when shell require to be thrown by hand amongst assailants or defenders of earthworks as at Rangiriri—when ricochet fire at very short distances is required, as at Orakau—the Armstrong field shell will always fail to be as effective as a common shell from a 24-pr. howitzer. Therefore the same arguments which held good for associating 24-pr. howitzers with 9-pr. guns in the old smooth-bored batteries, still apply to the necessity for associating an improvement on the 24-pr. howitzer with the 12-pr. Armstrong."*

A favourable opinion is given also by Colonel E. A. Williams, C.B., who commanded the Artillery in New Zealand in 1864:—

"As far as I could judge," he writes, "the Armstrong field guns stood the exposure and rough usage incidental to campaigning wonderfully well.

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* Vide Vol. IV. pp. 387-88.

"The accuracy of their fire was considerable, but I do think that the fuzes are too delicate, or perhaps I should say they require too delicate handling for field guns when under fire.

"We travelled some 6-prs. with columns of infantry, and they were useful in getting long shots at parties of natives, and never impeded the march."*

Let us now see how the Armstrong guns answered for Naval Service.

On the 15th and 16th August, 1863, five of our ships were engaged at Kagōsĭma, Japan, and judging generally from the reports forwarded to the Admiralty,† the guns behaved very well; the practice of 110 and 40-prs. at 4000 yards was admirable, and the shells with the new pattern pillar fuzes proved most destructive projectiles, but some jamming of vent pieces occurred on board the "Euryalus," six old pattern vent pieces were cracked in 77 rounds, and two instances occurred on board the "Perseus" of vent pieces having been blown away, in consequence it was supposed of there being no indicators to show that the breech screw was not properly screwed up. The evil is however incidental to this system of breech-loading.

Vice-Admiral Sir Augustus Kuper, the commander-in-chief in China at the time, states,‡ that from observations during this engagement he has formed a very high opinion of the Armstrong guns as regards the precision, force, and destructive power of their projectiles, but he considers the liability of vent pieces to split or jam, and the care required in screwing them up are great drawbacks to the general efficiency of the Armstrong gun for naval purposes; and when, as at Kagōsĭma, an action is fought in bad weather, the vent pieces and cartridges are necessarily much exposed to wet, causing serious delay by missfires.

The action of the Straits of Simōna Sek-i had followed that of Kagōsĭma in little more than twelve months, and four of the ships engaged in the second operation were concerned in the first.

"No substantial change had taken place in the ships' armaments, the accidents and defects reported bear, as would be expected, much the same character. No case is reported of a vent piece having been blown out on this occasion, although a serious escape of gas took place in one instance; a proof, perhaps, of improved training and greater experience. The *matériel*, however, was still of an early date, and not calculated to do justice to the powers of the guns with all the improvements of detail that have been applied within the last two or three years."§

The next and last engagement was that of the "Galatea" at Cape Haytien, in 1866, and the guns with all the "improvements of detail" showed their powers to advantage.

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* Letter to Captain Stoney, March 1, 1868.

† O.S. Committee Extracts, Vol. I. p. 400. The "Extracts from the Reports and Proceedings of the Ordnance Select Committee" are published regularly every quarter (since June 30, 1862). They contain a well arranged summary of the facts connected with every professional subject discussed by the O.S. Committee.

‡ O.S. Committee Extracts, Vol. II. pp. 93.

§ Ibid. Vol. III. p. 23.

"During the time the 'Galatea' was in commission, target practice was carried on satisfactorily with the Armstrong guns, and at Cape Haytien, where they were first tried in earnest, they answered extremely well.

"The forts being some little distance inland, and the range varying from 2000 to 2500 yards, they made very accurate practice, and proved themselves to be very superior guns. On this occasion about eighty rounds were fired from each pivot 7-in. breech-loading gun, and twenty rounds from each of the two broadside 7-in. breech-loading guns.

"The guns kept cool the whole time, and not the slightest accident occurred.

"The same vent-piece was used at each gun the whole day.

"The fuzes did not answer so well, the E fuze not bursting the shell beyond 1900 yards and very often acting prematurely, so that in the latter case, did the ship wish to land men under cover of shell firing, the formidable Armstrong shell could not be used; and in the former case, pillar fuzes had to be used and acted well at long ranges, though many of these also burst the shells prematurely.

"The 20-pr. is too large for a field gun. It is too heavy and too violent in recoil for boat service, and the ammunition is too complicated.

"The 12-pr. answers extremely well as a field gun."*

From the foregoing testimony, which is no one-sided selection, it will be admitted, that although the Armstrong guns did not play their part so perfectly well in the heat of action as at their quiet rehearsals at Shoeburyness, their performance on the whole was excellent and fully justified their adoption by the government.

Rome was not built in a day, nor was it to be expected that any system of rifled artillery could, like the mythic Minerva, be brought complete and perfect into existence by one blow of a blacksmith's hammer.

The foreign nations most advanced in the arts of war, have not succeeded better than ourselves.

"Every power in Europe which took an initiative in adopting rifled field artillery, has had to purchase its experience in a similar manner.

"The present French gun is not the gun of the Italian campaign, and their changes of ammunition have been very numerous.

"The Austrians adopted the system La Hitte in 1859, changed it for Lenk's system in 1860, and changed again in 1862. The Prussians adopted Wahrendorf's system in 1860, and changed it for Wesener's in 1863, and have since adopted Krainer's."†

French and Prussian guns on active service.

In fact the French guns used at Solferino and Magenta, though far superior to smooth-bore guns, were far from perfect, according to our present ideas of rifled guns.

In the Spanish expedition to Tetuan, (Feb. 1860), there were seventy French rifled field guns, and Capt. A. W. Duncan, R.A., who was an eye-

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* O.S. Committee Extracts, Vol. IV. p. 230.

† Ibid. p. 205.

witness at the principal engagements, declares that the practice was very bad. "The shell firing particularly so; most of the shells bursting at the muzzle, and not one in twenty taking effect. The shot were generally badly pitched and fell short of the enemy, and as the ground was undulating and in many places very rough, they went altogether out of the line of fire, and clean missed the columns of Moors."*

Lieut. Hozier, who accompanied the Prussian army into Bohemia in 1860, states, "that during the late campaign, not more than five out of every seven Austrian shells burst, and those that did burst did little comparative damage, the bursting charges being apparently too powerful for the rifled projectiles, and as far as he could follow the course of the shells fired from the Prussian rifled batteries, he is inclined to think even more Prussian than Austrian shells fell blind, and many that did burst, burst short and high, and could not have done much harm."

He thinks that the Armstrong guns (Lieut. Hozier served in China in 1860), when first introduced into the service with inexperienced gunners, did better work than the Prussian guns in this campaign.

Two of the Prussian steel rifled guns burst at Sadowa, and some other instances having occurred about the same time at Berlin, while cadets were at practice, the confidence of some Prussian authorities in steel as a material for guns was shaken, and they felt disposed to wish for coiled wrought-iron. Again, a steel 4-pr. gun unexpectedly burst at Tegel near Berlin 27/9/67, and killed the Director of the Artillery Depot and a gunner;† and in July, 1867, a Krupp's steel 9″ gun burst on board the Russian frigate "Alexandra Nwsgi" while the men were at practice. One officer and 11 men were killed and one officer and 29 men were wounded, and the ship was greatly damaged. And more recently two other 9″ Krupp guns burst during ordinary experiments, the one in Russia and the other at Cadiz.

Wedge and Shunt Guns Introduced.

Notwithstanding the progressive excellence of his breech screw guns, Sir William Armstrong introduced not only two natures of wedge guns (40-prs. and 64-prs.) as an improvement on the breech screw arrangement in points of safety and simplicity, but also 64-pr. muzzle-loading guns with shunt rifling, and proposed other shunt guns of larger calibre.

As was natural however in this mechanical age and country, Sir William Armstrong was not permitted to bear away the palm without a contest.

Various propositions for rifled guns were submitted to the O.S. Committee, and in 1858 General Peel, the then Secretary of State for War, "called upon Colonel Lefroy, his scientific adviser, for a report on all the experiments that had been tried on rifled ordnance, and in accordance with the recommendation of that report appointed a special committee to examine as to what was the best rifled gun for field service. This committee came to the conclusion that it was not expedient to incur the expense of trying further experiments with any except those of Messrs Whitworth and Armstrong.

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* Letter to Captain Stoney, March 21, 1868.

† O.S. Committee Extracts, Vol. V. p. 296.

The trial accordingly took place, but as at that time Mr Whitworth did not propose any gun of his own construction, and had only rifled government blocks of brass and cast-iron, the Armstrong breech-loading gun which was complete in every respect was, as we have seen, adopted. Nothing daunted, however, Mr Whitworth carried on a series of private experiments, and having perfected his plans, he obtained such good results with his guns that he again challenged the rival system which the government had adopted.

The Armstrong and Whitworth Committee appointed.

A special committee* was then appointed, 1st June, 1863, to examine and report upon the different descriptions of guns and ammunition proposed by Sir W. Armstrong and Mr Whitworth.

The enquiry was to embrace the comparative qualities of the several systems with respect to range, accuracy, endurance, ease of working, cost, &c., the fitness, in short, of the guns and ammunition for the various purposes to which ordnance may be applied either in land or sea service.

The committee accordingly made patient and extensive competitive experiments with Whitworth 12-prs. and 70-prs., Armstrong 12-prs. and 70-prs. breech-loaders, and Armstrong 12-pr. and 70-pr. muzzle-loaders; the 12-prs. having been chosen to decide the question for field artillery, whilst the 70-prs. were the best available representatives of heavy artillery, comprising siege, garrison, and broadside guns.

Both natures of the Whitworth guns were muzzle-loaders, and had his well-known hexagonal rifling, and mechanically fitting projectiles.

The 12-prs. were of solid mild steel (having trunnion rings screwed on to them), with a hoop of the same material over the powder chamber.

The 70-prs. were of the same material, but consisted of an inner tube closed by a breech-screw and strengthened by hoops pressed on cold by hydraulic pressure.

The Armstrong breech-loaders were constructed with steel barrels, and with wrought-iron coils superimposed as usual, but the 12-prs. had the ordinary breech screw arrangement, and the 70-prs. were upon the wedge system.

His muzzle-loaders also had inner barrels of steel; they were rifled on the shunt principle, for projectiles with soft metal studs.

After a searching examination of important witnesses, and complete and comprehensive trials which cost £35,000 for stores alone, the committee concluded their labours, on the 3rd of August, 1865, which is the date of their reports.

The results of these experiments were very creditable to both inventors, especially as regarded the construction of their respective guns, each of which after firing about 3000 rounds was only burst at last by abnormal means.

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* This Committee consisted of Major-General Rumley; Major-General A. J. Taylor, R.A.; Colonel J. W. Ormsby, R.A.; Captain T. Wilson, R.N.; Colonel J. L. A. Simmons, R.E.; Major C. F. Young, R.A.; Mr J. C. McDonald; Mr S. Rendel; Major H. S. Dyer, R.A., Secretary.

Conclusions arrived at by the Committee.

The report was on the whole most in favour of the Armstrong muzzle-loaders for the following reasons, which among points of the utmost importance to gunnery, the committee established in the course of their experiments:—

"That the many-grooved system of rifling with its lead coated projectiles, and complicated breech-loading arrangements, entailing the use of tin cups and lubricators, is far inferior for the general purposes of war, to both of the muzzle-loading systems, and has the disadvantage of being more expensive both in original cost and in ammunition.

"That muzzle-loading guns can be loaded and worked with perfect ease and abundant rapidity.

"That guns fully satisfying all conditions of safety can be made with steel barrels strengthened by superimposed hoops of coiled wrought-iron, and that such guns give premonitory signs of approaching rupture; whereas guns composed entirely of steel are liable to burst explosively without giving the slightest warning to the gun detachment."

These remarks are not supposed to be limited to heavy guns, they apply with equal or greater force to field guns; in fact, the committee expressed their opinion that both Sir Wm Armstrong's and Mr Whitworth's muzzle-loading systems, including guns and ammunition, are on the whole very far superior to Sir Wm. Armstrong's breech-loading system for the service of artillery in the field.

Question of M.L. Rifled Guns for Field Service.

This startling conclusion led to further enquiry; a new committee, consisting of Sir R. Dacres as president, and 12 experienced R.A. officers of high rank, as members, was appointed in 1866 specially to investigate the subject, and according to Lieut.-Col. Miller, Secretary, the actual terms of this committee's decision are,* "That the balance of advantages is in favour of M.L. field guns, and that they should be manufactured hereafter."

The general reason for coming to this result is briefly summed up by Lieut.-Col. Miller as follows:—

"If we had to take immediate part in a European war we should bring into the field a delicate gun requiring constant care and a great variety of stores for its sole use;† we should further be liable to the risk of the gun failing us at critical moments, but we should not have the satisfaction

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* See paper entitled "The comparative advantages of breech-loading and muzzle-loading systems for Rifled Field Artillery.—"Proceedings" R.A. Institution, Vol. V. p. 312.

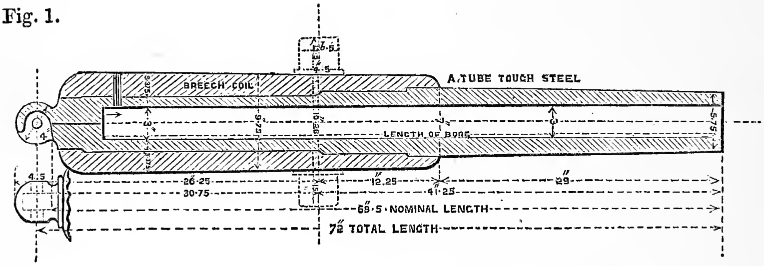
† "Each battery, in addition to spare articles connected with the breech-loading apparatus, is supplied with a box of facing implements weighing 105 lbs,, and containing 25 articles required for re-facing the vent pieces and bouche rings, and with a set of special tools in two boxes, together weighing 83 lbs., containing a large number of articles."—Report of the Armstrong and Whitworth Committee, p. xxxi.

of getting any advantage in range, accuracy or rate of fire which would not equally be presented by a muzzle-loading system."

These observations have greater weight since the last Austro-Prussian war shewed us that future campaigns in Europe will be carried on with colossal armaments and the utmost dispatch. About 800 field guns accompanied each of the hostile armies, and though our taking the field with such a number of guns is out of the question, it is imperative upon us to simplify our *matériel* as much as possible.

However, the adoption of the committee's recommendation is in abeyance on account of the great expense of at once re-arming all our field artillery with muzzle-loading rifled guns, but it is improbable that B.L. guns will be made in future to any extent except for boat guns for which service they are very suitable, and in this year's estimate (1868, 9), there are twenty 12-pr. M.L.R. guns of an approved pattern, which perhaps will be adopted eventually for field service; these guns are to consist of coiled wrought-iron exteriors and solid ended steel tubes, toughened in oil and rifled on the "Woolwich" system. Fig. 1 will show the general shape and dimensions.

Fig. 1.



So far for field artillery. We must now turn to the question of heavy guns, which is a very important one to such an essentially naval nation as ourselves.

Necessity for heavy M.L. Rifled guns.

The power and precision of rifled guns and the growing use of concussion shells which would burst on striking on a ship's side and make a hole beyond repair, or having penetrated, would burst between decks, dealing death and destruction around, and probably setting fire to the vessel, necessitated the use of ironclads.* To penetrate these necessitated in turn still

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* The power of horizontal shell fire was perceived only forty years ago; the French then adopted the Paixhans shell gun, and Gen. Millar, R.A. introduced our 10-inch and 8-inch shell guns; the new species of fire, however, lay dormant for many years, but at length woke up by war, its development advanced *pari passu* with that of rifled ordnance. Nearly all the naval engagements which have taken place of late years furnish instances of the destructive effect of shells on wooden vessels:—

At Sinope, during the Crimean war, the Turkish fleet was actually destroyed by Paixhans' explosive shells fired from the Russian vessels "Constantine" and "Paris."

In the recent American war the iron-clad "Merrimac" blew up by shells the wooden vessel more powerful guns, and then commenced the Shoeburyness campaign of guns *versus* armour plates, which is not yet decided.

The judgment which the Armstrong and Whitworth Committee pronounced in favour of muzzle-loading guns was only in accordance, so far at least as heavy guns were concerned, with the preconceived opinion of our leading artillerists, for any breech-loading arrangement with guns using the enormous charges required would not only be too cumbrous but actually unsafe.*

As the striking effect of a projectile depends more on its velocity than on its weight, and as a round shot fired from a smooth-bore gun has considerably greater initial velocity than an elongated shot fired from a rifled gun, owing to the friction in the bore of the latter, as well as to its smaller proportionate charge, the Admiralty at first proposed wrought-iron smooth-bore guns of large calibre to penetrate armour-plated vessels at close quarters; accordingly in 1864, after mature experiments, two natures of wrought-iron smooth-bore guns were adopted; these were the 100-pr. of 9″ calibre, and the 150-pr. of 10·5″ calibre. They were built-up on the Armstrong coil principle, but only about a dozen of the former, and fifty of the latter were made, as it soon become evident that still more potent guns were necessary, and that we could make them too in the shape of wrought-iron M.L. rifled guns. In fact, such good results were obtained from the 64-pr. M.L. shunt gun (which was approved as a sea service gun March 10, 1865), as well as from larger experimental guns on the same system of rifling and construction, that the O. S. Committee suggested, (Report No. 3553, 25/11/64), that the above two natures of smooth-bore guns should be also rifled on the shunt system.

These guns, however, remained as they were, Colonel Campbell, Superintendent Royal Gun Factories, having pointed out that they were much too weak longitudinally for rifled guns, an opinion which has since been verified, two of the smooth-bore 150-prs. having blown the breech out during practice.

But the shunt rifling itself was eclipsed in 1865 by the "Woolwich" system, and as the steps which led to this result throw considerable light on the whole system of rifling, they will be briefly referred to.

Competition to ascertain the best mode of rifling.

By instructions first received from Lord Herbert in 1859, the O.S. Committee carried on an extensive trial of cast-iron 32-pr. guns rifled for different gentlemen in accordance with their respective views of the best way of rifling the existing store of smooth-bore cast-iron guns.

"Congress," having first made dreadful havoc of the crew; and the "Kearsage" sunk the "Alabama."

Lastly, at Lissa the Italian vessel "Palæstro" (partially plated) was destroyed by the Austrian shells.

* There is no doubt that breech-loading guns, if they could be made sufficiently safe and simple, would be very superior to muzzle-loaders for certain purposes, such as casemate, broadside and cupola, and perhaps too in connexion with Capt. Moncrieff's new "lift" gun carriage.

The result of this competition, upon which the O.S. Committee* reported 3rd Feb. 1863,† proved that cast-iron was altogether too weak and precarious a material for rifled guns.

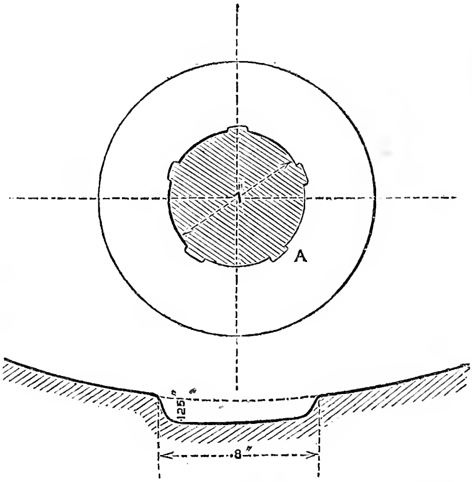
The trial was then extended to wrought-iron guns, rifled on the respective systems of Commander R. A. E. Scott, R.N., Mr Lancaster, Mr Jeffrey, and Mr Britten, who with Messrs Lynal Thomas, Hadden, Nasmyth, and Whitworth, were rivals in the cast-iron competition.

At the request of the O.S. Committee, a gun rifled with French grooves was added, and finally a shunt gun also was tried in comparison with the others.

All the guns selected for competition were 7″ muzzle-loading guns of 7 tons, built on the Armstrong coil principle, and having inner barrels of steel.

Commander Scott's gun was rifled in five grooves, which were shallower on the loading side than on the driving side, which was curved with a view to obtain a perfect centering for his shot. His rifling had a uniform spiral of one turn in 294 inches. Fig. 2.

Fig. 2.



His projectile at first had simply five iron ribs, with two very small copper studs inserted in the driving face of each, but afterwards the ribs were faced with zinc.

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* The Ordnance Select Committee at that time consisted of—

Brigadier-General St George, C.B., R.A., *President.*
Capt. Sir W. Wiseman, Bart., R.N. }
Brevet-Colonel Hogge, C.B., R.A. }
Brevet-Colonel F. A. Campbell, R.A. } *Members.*
Lieut.-Col. R. S. Baynes (Unattached). }
Lieut.-Colonel Gallwey, R.E. }
Brevet-Colonel Lefroy, R.A., *Secretary.*

The Report is published in the "Proceedings," R.A. Institution, Vol. III. p. 323, as well as in the O.S. Committee Extracts, Vol. I. p. 174.

† Great delay occurred in consequence of the competitive guns not being ready; Mr Whitworth, for instance, did not deliver his gun in a rifled state until August, 1862.

Mr Lancaster's gun was oval bored, the major-axis being 7·6″, and the minor-axis 7″. The rifling making one turn in 360″. Fig. 3.

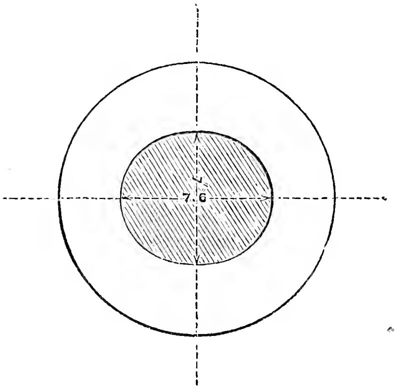

Fig. 3.

One gun was sufficient for Messrs Jeffrey and Britten, as their systems differed from one another only in manner of applying lead to the base of the projectile so that it might take the rifling.* Both these guns had 13 grooves 0·10″ in depth, and ·846″ in width, and a turn of 1 in 805″. Fig. 4.

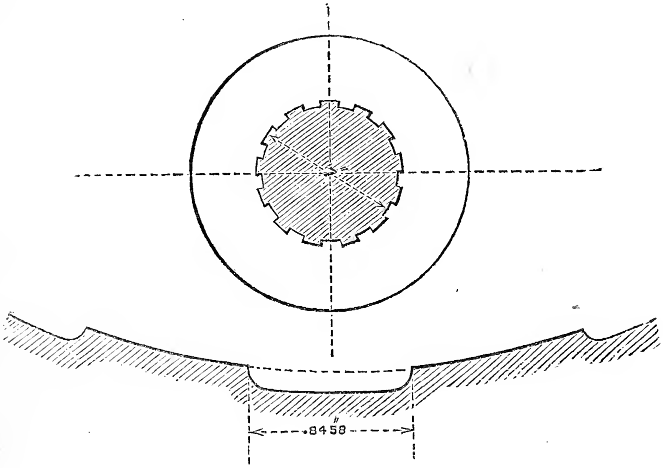

Fig. 4.

The French gun was rifled in 3 grooves 0·225″ deep, 2·02″ wide, the rifling gradually increased from nothing at the breech to 1 turn in 259″ at the muzzle.† The first batch of projectiles for the French gun had three large half-zinc studs in front, supported by an iron back, and three small ones behind, but as the experiments went on it was found expedient

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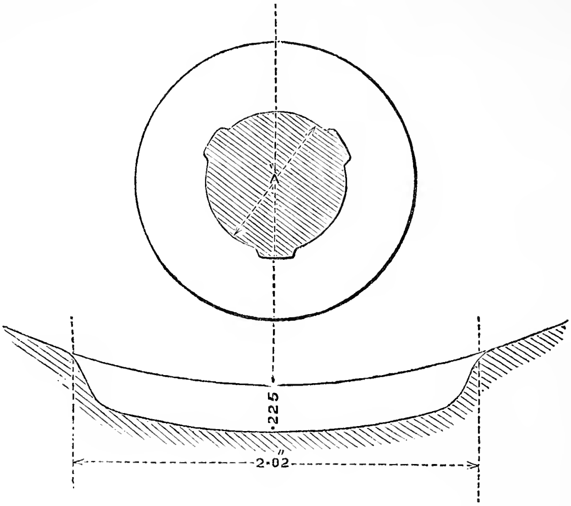
* Mr Britten's method of attaching lead coating chemically was adopted for the projectiles of the Armstrong B.L. guns, and has proved most satisfactory.

† The sections of the several grooves are full size, those of the muzzles are on a scale of ⅛th.

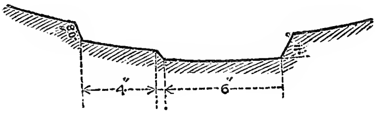
to adopt Major Palliser's proposal of changing the metal of the studs to gun-metal, and of reversing the position of the studs by placing the smaller ones in front. Fig. 5.

Fig. 5.



The shunt guns had six grooves of the well-known form; the spiral was uniform with one turn in 226″ or 38 calibres. The shot had 30 studs, i.e. five for each groove. Fig. 6 shews section at muzzle.

Fig. 6.



All the projectiles had hemispherical heads. The weight of each shell (filled) was 100 lbs. and of each shot 110 lbs., except that of the French shot which weighed only 100 lbs.

A very short experience showed that the systems of Messrs Jeffrey and Britten were unsuited for heavy charges; large pieces of lead were blown off the shot, and the shooting was so wild as to throw these systems entirely out of the competition, which therefore was limited to those of Scott, Lancaster, the French, and the shunt.

Experiments were carried on which tested these competitive guns in all the cardinal virtues of ordnance, and though the shooting qualities were alike, the O. S. Committee in their final report, No. 3730, dated 1st May 1865, recorded their unanimous opinion in favour of the so-called French system:—

(1) "Because of the simplicity of its studding on the projectiles.

(2) "The simplicity of the grooving of the gun, and

(3) "From a disposition to admit the advantages of an increasing over a uniform spiral."

And further, the committee recommended "that the heavy 7" guns then in course of manufacture should be rifled in the same manner as the competitive so-called French gun, except that the width and depth of the grooves should be slightly decreased, and that 8" and 9" guns also should be completed with similar rifling."* Fig. 7 shews a section of the modified groove.

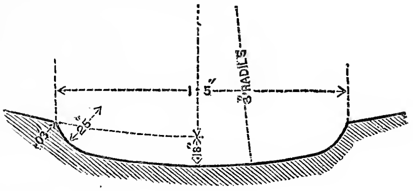


Fig. 7.

The Woolwich guns.

This was the origin of those powerful pieces of ordnance known by the comprehensive term of "Woolwich guns," a binomial which may be expanded into "wrought-iron muzzle-loading guns built on Sir William Armstrong's principles improved by Mr Anderson's method of 'hooking' the coils, and with solid-ended steel tubes toughened in oil and rifled on the French system, modified as recommended by the O.S. Committee for projectiles studded according to Major Palliser's plan."

In the course of 1865, 6, the Woolwich guns manufactured on this "original construction," were as follows:—

176........	9"	of 12 tons.
71........	8"	" 9 "
46........	7"	" 7 "
328........	7"	" 6½ "

So far as strength and efficiency were concerned, these guns were nearly all that could be desired, but their expense, £100 a ton in round numbers was a serious point, and to diminish it Col. F. A. Campbell who succeeded Sir W. Armstrong as Supt. Royal Gun Factories in 1863, set practically and patiently to work. Two questions presented themselves for solution.

(1) Could not a coarser and cheaper iron be obtained which would be sufficiently strong for the exterior of the gun?

(2) Could not the guns be constructed in a simpler and cheaper form?

By personal visits to most of the leading ironmasters, and a series of experiments, Colonel Campbell had already found a very superior and satisfactory iron for the inner barrels of B.L. guns,† and by following up his

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* See Extracts from O. S. Committee Proceedings, Vol. III. p. 154, or "Proceedings" R.A. Institution, Vol. IV. p. 410.

† Previous to the adoption of Marshall and Mills charcoal iron for inner barrels, two barrels out of every three were rejected for defective welds, blisters, &c. and Mr John Anderson, the then Assist.-Supt. Royal Gun Factory was obliged to have recourse to the questionable expedient of forming inner barrels from solid forgings.

success he now obtained a very cheap iron sufficiently strong for the exterior of our heavy guns, whilst in the plan of construction proposed by Mr R. S. Fraser, C.E,, R.G.F., he discerned a still more gratifying solution to the second question.

The result of this double event was to decrease the cost of the guns by one-third, and a very considerable sum has thereby been saved already, not to mention the probable saving in our future estimates; and further economy is likely to take place from the home manufacture of wrought-iron in the Royal Gun Factories. Scrap iron, old musket barrels, &c., &c., has for some time back been converted into bar iron, but recently puddling furnaces, and a rolling mill have been erected, and excellent gun iron is made from the useless stock of obsolete cast-iron ordnance.

So that it is not impossible that carronades which boomed at Trafalgar and muskets which rang at Waterloo may again in their renovated form contribute to our future victories.

The Fraser guns.

The new or "F construction" (as it is officially designated) having successfully stood a long course of severe tests, was adopted for service at the close of 1866. It differs principally from the original or Armstrong construction in building-up a gun with a few double or triple coils instead of several finely-finished and accurately gauged single ones, and as there is so much less surface to be prepared a proportionate expense is saved, just as in book-binding, it is cheaper to get a book bound in one thick volume instead of in two or three thin ones.

A double coil is made simply by winding a bar of red hot iron over one previously coiled in the reverse direction, and then welding and preparing the mass as a single coil. A triple coil is formed similarly, three bars being wound one over the other.

Greater strength as well as less expense is claimed for the F system, as the greater the number of parts in a gun the more probability is there that some weakness will exist in the mass, as it is impossible to shrink on each part with its proper amount of tension or strain.

Moreover the trunnion ring, which originally was merely shrunk on is now *welded* to the breech-piece, so there is no fear of it shifting forward, as was sometimes the case with the early Armstrong guns.

But the difference of construction will be best understood by inspecting a section of a 9″ gun on each system. See Figs. 8, 9.

The solid-ended steel tube, forged from a cast ingot bored out and toughened in oil is common to both, as is also the cascable screw of solid forged wrought-iron; in addition to these the original construction has a

Fig. 8.

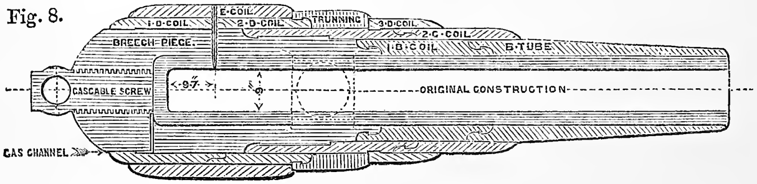
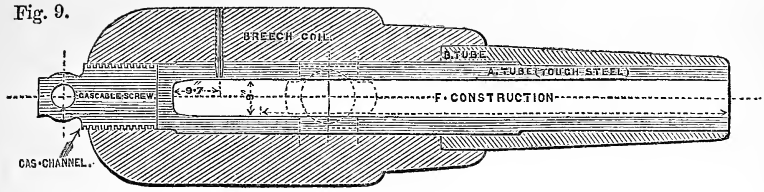


Fig. 9.



breech piece, a B tube, a trunnion ring, and 7 coils—ten distinct parts which are shrunk on separately. Whereas the F construction has only two separate parts or shrinkings, viz. the B tube and the breech coil. Some of the earlier Fraser guns have a breech piece, but as this appeared superfluous with a solid-ended steel barrel, the simpler construction given in the example, was approved, and is the one on which all our heavy guns are now built.

The following table gives the details of our wrought-iron rifled guns of each construction.

TABLE

SHOWING DIMENSIONS, RIFLING, &C., OF WROUGHT-IRON MUZZLE-LOADING RIFLED GUNS.

Nature, weight, and service.	Length of			Rifling.		Grooves, see note p. 98.	Radii for sighting.		Permanent angle of deflection of sights.	Weight of projectile.	Preponderance.	Charge.	
	Gun.	Bore.	Rifling	System. *a*	Spiral, 1 turn in no. of calibres.		Side.	Centre.				Service.	Battering.
	ft. in.	in.	in.				in.	in.		lbs.	cwt.	lbs.	lbs.
13·05″ of 23 tons (original construction).*	14 1	141·5	126·	W	Unif. 1 in 55 cals. of 13″	N. 10 D. ·2 W. 1·5	45	45·1	vertical	600	The preponderance of all guns above 12 tons weight is between 5 and 6 cwt.	50	70
12″ of 23½ tons (original construction). ...	14 3½	145·	127·	〃	*b*	N. 9 D. ·2 W. 1·5	—	—	—	—		50	70
12″ of 25 tons (F construction).†	14 3½	145·	127·	〃	*b*	N. 9 D. ·2 W. 1·5	—	—	—	—		50	70
11″ of 23 tons.	14 1	145·	120·		In. fr.1 in100to 1 in 45	— D. ·22 W. 1·5	—	—	—	—			
10″ of 18 tons.	14 2	145·5	118·	〃	do to 1 in 40	N. 7 D. ·2 W. 1·5	54	·54	1° 16′	400		40	60
9″ of 12 tons L.S. and S.S. (original construction).‡	12 3	125·	107·5	〃	In.fr.0 to 1 in 45	N. 6 D. ·18 W. 1·5	45	45·1	44′	250	Nil	30	43
9″ of 12 tons (F construction).	12 3	125·	107·5	〃	〃	N. 6 D. ·18 W. 1·5	45	45·1	44′	250	5	30	43

* Only two in the service.
† The F or Fraser construction, is now the service construction.
‡ The service charge for a M.L. R. gun is about ⅛th the weight of the projectile, and the battering charge ⅙th.
a Woolwich.
b Increasing, from 1 in 100 at breech to 1 in 50 at muzzle.

TALBE—*continued*,

SHOWING DIMENSIONS, RIFLING, &c.

Nature, weight, and service.	Length of			Rifling.		Grooves, see note p. 98.	Radii for sighting.		Permanent angle of deflection of sights.	Weight of projectile.	Preponderance.	Charge.	
	Gun.	Bore.	Rifling	*a* System.	Spiral, 1 turn in no. of calibres.		Side.	Centre.				Service.	Battering.
	ft. in.	in.	in.				in.	in.		lbs.	cwt.	lbs.	lbs.
8″ of 9 tons S.S. (original construction).	11 4½	118·	102·	W	Incr. 1 in 40	N. 4 D. ·18 W. 1·5	38	38·1	28′	180	Nil	20	30
8″ of 9 tons (F construction).	11 4½	118·	102·	〃	〃	N. 4 D. ·18 W. 1·5	38	38·1	28′	180	4	20	30
7″ of 7 tons L.S. (original construction). ...	11 10·8	126·	112·5	〃	Unif. 1 in 35	N. 3 D. ·18 W. 1·5	38	38·1	3°	115	4·5	14	22
7″ of 7 tons (F construction).	11 9½	126·	112·5	〃	〃	N. 3 D. ·18 W. 1·5	38	38·1	3°	115	3	14	22
7″ of 6½ tons S.S. (original construction).	10 5¼	111·	97·5	〃	〃	N. 3 D. ·18 W. 1·5	38	38·1	3°	115	5·5	14	22
7″ of 6½ tons (F. construction).	10 6½	111·	97·5	〃	〃	N. 3 D. ·18 W. 1·5	38	38·1	3°	115	3	14	22
64-pr. of 64 cwt. S.S. (original construction).*.................	9 3½	98·	90·5	S	Unif. 1 in 40	N. 3 D. ·11 & ·08 W. ·6 & ·4	38	38·1	2° 16′	64	7	8	—
64-pr. of 64 cwt. (B pattern) S.S.†.........	9 5½	98·	90·5	〃	〃	N. 3 D. ·11 & ·08 W. ·6 & ·4	38	38·1	2° 16′	64	3	8	—
64-pr. of 64 cwt. (D pattern) S.S.	9 3½	97·5	90·5	〃	〃	N. 3 D. ·11 & ·08 W. ·6 & ·4	38	38·1	2° 16′	64	3·75	8	—

Royal Gun Factory,
June 1868.

(Signed) F. A. CAMPBELL, Col. R.A.
Superintendent, R.G.F.

a Woolwich and Shunt.
* Calibre is 6·3″ to take the 32-pr. S.B. ammunition on an emergency.
† Both F. guns, but the B. pattern has a forged breech-piece, and the D a breech coil of one thickness.

From what has been remarked, it is scarcely necessary to add that the guns in the foregoing table are the most important we have, but it may be useful to notice briefly each nature.

Specialities of the various natures of Woolwich guns.

There were about half a dozen 13″ guns made for experimental purposes, and rifled on the shunt principle; two of these were re-rifled in 1866 on the Woolwich system, and were intended for Gibraltar, where, however, they were never sent (this accounts for their appearance in the table), but 12″ is the highest calibre approved for service, the projectile, however, is the same, 600 lbs. By the end of this year we shall have 22 of these powerful guns; 4 of them are already allotted to the double-turreted iron-clad "Monarch," which was launched last May. It is to be noted that at the rate of 5 tons of metal for every 100 lbs. of shot (which seems to be about the correct proportion of weight for Woolwich guns) the 12″ gun is too light for 600 lb. projectiles and the usual proportionate charges of rifle L.G. powder.

Only one 11″ gun has as yet been ordered, and the details are not decided.

The 10″ guns will also be used in turret vessels, 18 are ordered but none are yet completed for service. The experimental gun at Shoeburyness has penetrated a 15″ plate at 200 yards.

The 9″ gun is a very powerful and efficient gun for its weight; with chilled shot and battering charges (43 lbs.) it can penetrate 8″ armour plates at 200 yards, it will therefore be much used in the navy. 255 have already (1st June 1868) been manufactured.

The 8″ gun is for sea service only, 96 manufactured. The 7″ of 7 tons or the land service pattern is a longer gun and a better shooter than the 6½ ton gun which is superseding the 7″ B.L. gun in a certain class of frigates. 62 of the heavy pattern manufactured, and 515 of the light.

The 64-pr. was originally intended for a B.L. gun, but was completed as a muzzle-loader, it is used only as a naval shell gun. 430 manufactured.

All the 64-prs. in the service have coiled wrought-iron barrels and shunt rifling, whilst all the higher natures (except a few individual guns) have steel barrels, and the "Woolwich" rifling.

Our own and foreign guns compared.

At this point it may not be uninteresting to allude to the heavy ordnance of foreign nations in comparison with our own.

Most of the continental powers at first rifled their old cast-iron guns and strengthened them with exterior hoops of steel or wrought-iron, but more recently they have been supplying themselves with steel guns manufactured by M. Krupp, of Essen;* whilst the Americans, who had the most urgent

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* The enormous scale on which M. Krupp's works are conducted will be understood when it is stated that they cover about 450 acres of ground, about one-fourth of which is under cover, that the number of men employed is 8000, besides 2000 more in the coal mines at Essen, at the blast furnaces on the Rhine, and at the iron pits on the Rhine and in Nassau; also, that during last year the produce of the works was 61,000 tons, by means of 112 smelting reverberatory, and cementing furnaces; 195 steam engines, from 2 to 1000 horse power; 49 steam hammers, from 1 to 50 tons (the blocks); 110 smiths' forges; 318 lathes; 111 planing machines; 61 cutting and shaping machines.

The establishment has already delivered 3500 guns, valued at over £1,050,000, and it has received orders for the immediate delivery of 2200 more. Most of the guns made are rifled breech-loaders, from 4-prs. to 300 prs.

At the Paris Exhibition 1867, M. Krupp exhibited a 1000-pr. weighing 50 tons, and a 330-pr. of 12¼ tons, besides smaller guns, all breech-loaders.

The 1000-pr. (which he has presented to the King of Prussia) has a forged inner tube strengthened with three layers of rings over the powder chamber, and two layers over the muzzle portion; the rings are forged from ingots without welding.

necessity of all for heavy and powerful guns, rifled some hooped cast-iron guns on Parrott's plan, but they place greater reliance in smooth-bore guns made from their excellent cast-iron on Rodman's plan.

With regard to the hooped cast-iron guns it is well known that the vent is the vulnerable part of a cast-iron gun, and even if the piece were strengthened sufficiently to bear the increased strain, the part adjoining the vent would rapidly wear away, and cause the destruction of the gun. As for steel, its treacherous and apoplectic nature renders it a dangerous material for *large* guns, and gunners would do well not to trust it until greater improvements take place in its manufacture.

The large American smooth-bore guns shaped somewhat like a soda water bottle, as suggested by Captain Dahlgren, United States Navy, and cast hollow, and cooled from the interior as proposed by Captain Rodman are, for cast-iron guns, the best that can be manufactured, and are no doubt very formidable pieces, but weight for weight they are inferior to our muzzle-loading rifled wrought-iron guns.

For, supposing the American cast-iron guns are as durable and as little liable to burst as our sinewy guns of wrought-iron, and that their apocryphal charges are actually used, our guns possess the great advantage of being able to *pierce* armour plates with shot, nay even with *shell,* which the American guns could only crush or "rack" with solid shot; but perhaps this statement wants some demonstration.

Mode of estimating gun power.

Now the correct mode of estimating gun power is to calculate the *vis-vivâ* $\left(\frac{Wv^2}{2g}\right)$ or the dynamical force of the shot at various ranges, but to find out the comparative penetrative effect against armour plates it is necessary to divide the *vis vivâ* by the diameter of the shot, for it is one of the laws established by experiment* that when the projectiles are of a hard material, such as steel or chilled iron, the perforation is directly proportional to the "work," (*vis vivâ*) in the shot,† and inversely proportional to its diameter.

In order therefore to compare our modern heavy guns with their rivals as well as with their predecessors, the actual *vires vivæ* (in foot tons) of representative guns are given in the following table.

The manufacture of this gun continued during night and day for sixteen months, and the cost of the piece is £15,750. The breech-loading arrangement is complicated, and some time would be necessary to go through the different operations in loading. (Report on the artillery at the Paris Exhibition by Lieut.-Colonel C. H. Owen, R.A., in the "Illustrated London News," August 31, 1867).

* See Captain W. H. Noble's valuable Report on the penetration of armour plates, a blue book published 1856 by the War Office.

† "Energy" has lately been used as an equivalent for *vis vivâ,* but it is scarcely expressive enough unless we call to mind its Greek derivation.

The velocities (in feet per second) are also given, as they were necessary to the calculations, and it is as well to record them.

Gun.	Weight of gun.	Weight of shot.	Charge.	Initial velocity.	At 200 yds.		At 1000 yds.		At 2000 yds.	
					Velocity.	*Vis vivâ.*	Velocity.	*Vis vivâ.*	Velocity	*Vis vivâ.*
		lbs.	lbs.	ft.	ft.		ft.			
68-pr. S.B. gun ...	95 cwt.	66	16	1580	1380	878	986	445	717	235
7″ B.L., B.S.......	82 〃	90	11	1165	1118	771	962	577	820	412
7″ M.L. R. gun...	6½ tons	115	22	1430	1360	1505	1199	1146	1034	862
9″ 〃 ...	12 〃	250	43	1340	1330	3069	1175	2394	1046	1896
10″ 〃 ...	18 〃	400	60	1290	1265	4438	1168	3784	1068	3163
12″ 〃 ...	23 〃	600	70	1240	1217	6161	1133	5336	1042	4520
American 15″ S.B.	20 〃	450	100*	1543	1454	6597	1182	4359	958	2863
〃 20″ 〃	50 〃	1100	200*	1370	1316	13210	1136	9843	971	7191

The *initial* velocity is taken principally from Captain Noble's abstract, O.S. Committee Extracts, Vol. V. pp. 168–71.

The calculations for the 12″ M.L. rifled gun and for the 20″ American are taken from the "Army and Navy Gazette," 11/4/68. A few of the numbers having been verified.

However the next table which is immediately deduced from the foregoing will perhaps be more popular, as it shows at a glance the *relative* powers of the guns, by giving their *specific vis vivâ*, taking that of the familiar 68-pr. *as unity*.

Nature.	Weight of gun.	Weight of shot.	Charge.	Specific *vis vivâ* of each gun.		
				At 200 yds.	At 1000 yds.	At 2000 yds.
		lbs.	lbs.			
68-pr. S.B. gun ...	95 cwt.	66	16	1	1	1
7″ B.L., B.S.R....	82 〃	90	11	·86	1·3	1·7
7″ M.L. R. gun...	6½ tons.	115	22	1·7	2·6	3·6
9″ 〃 ...	12 〃	250	43	3·5	5·4	8·0
10″ 〃 ...	18 〃	400	60	5·0	8·5	13·5
12″ 〃 ...	23 〃	600	70	7·0	12·0	19·2
American 15″ S.B.	20 〃	450	100	7·5	9·8	12·2
〃 20″ 〃	50 〃	1100	200	15·0	22·1	30·6

Thus we see, for example, that the 12″ gun can deliver a blow, on masonry say, at 1000 yards, twelve times as severe as the 68-pr. can. For the relative power of perforating armour plates we must divide by the respective diameters of their projectiles, or for simplicity by the calibres of the guns (which practically amounts to the same thing), and in this case we find that the 12″ gun is eight times as powerful as the 68-pr.

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* American powder and *alleged* charges. The Americans have as yet (June '68) only four 20″ guns, two of which ("Beelzebub" and "Puritan") were cast in May '66, and their 15″ guns are not very numerous.

In the same way the perforating effect of the 12″ gun at 1000 yards would appear to be nearly as much as that of the 20″ American gun which is more than double its weight, but in reality the 12″ gun has greater perforating power than the 20″ gun, as an ogival-headed or *gothic* shaped projectile is more adapted for penetration than a shot (no matter whether it be circular or *norman* in profile) with a round head. For strict comparison therefore, the rule only applies to shot of the same shape, and, I may add, of the same material also.

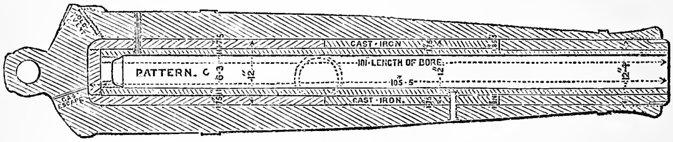
But stubborn facts are still more in our favour; at the recent experiments at Shoeburyness our 10″ gun of 18 tons penetrated 15 inches of iron (in 3 5″ armour plates), upon which the 15″ Rodman gun of 20 tons only made a shallow indent.

In fine, the investigation of the subject, whether by theory or practice, only serves to confirm the conviction that we have the best guns, as well as the best ammunition in the world. For our superiority in the latter respect we are indebted to the excellent powder manufactured at Waltham Abbey, and the exquisite fuzes and projectiles produced in the Royal Laboratory under the able superintendence of Colonel Boxer.

Major Palliser's guns.

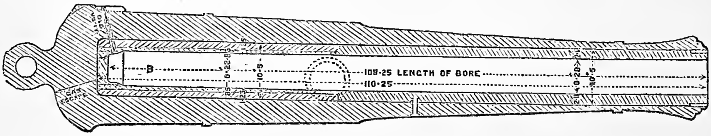
Major Palliser who has shown great practical talent in introducing chilled shot, improved armour bolts, mode of studding projectiles, &c. has for some years back been labouring at an expedient for converting our numerous cast-iron smooth-bore guns into rifled guns, by inserting a lining of coiled wrought-iron, and his experiments have been so promising in their results that the immediate conversion of several 8″ shell guns of 65 cwt. into 64-pr. rifled guns is contemplated. Fig. 10.

Fig. 10.



His method consists simply of boring up an old gun and inserting a coiled wrought-iron tube of the required calibre; in some instances (depending on the nature of the gun) this tube is double, the exterior fold being of cheap iron, or the exterior portion near the muzzle is of cast-iron. The tube is turned to fit the gun as exactly as possible, and being of wrought-iron it is "set up" or tightened in the gun by the proof rounds, whilst to make it still more secure in the gun a metal collar is screwed over it at the muzzle (see Fig. 11), and a pin is screwed into it through the chase of the gun.

Fig 11.



32-pr. C.I. gun of 58 cwt. converted into a rifled 64-pr.

Some guns thus constructed have shewn remarkable strength and endurance, and it is to be hoped that all those about to be converted may be equally satisfactory. There is no doubt about their circumferential strength or non-liability to burst the barrel, but some good authorities on the subject consider them longitudinally weak or liable to blow the breech off without any warning.

The cost of a converted gun is about two-thirds that of an F gun of similar calibre. In this estimate the old gun is supposed to have been useless as a gun, and worth only £3 a ton, and not a serviceable piece worth £21 a ton.

But the expense in gunnery is not so much the first cost of the gun as the ammunition it uses and the service it requires; for example, the ammunition for a 64-pr. costs at least a guinea a round, and if we add the price of 1000 rounds to that of the gun, we gain only 6 per cent. by adopting the Palliser system, whilst the difference between the cost of two live ships of war, the one with an armament of converted guns and the other with our more trustworthy wrought-iron guns, is appreciably nothing.

The efficiency, therefore, of a gun should not be sacrificed to economy of manufacture, unless under most pressing circumstances.

However whether Major Palliser's method proves in the end economical or not, he deserves notice for the ingenuity, energy, and perseverance he has displayed in the matter.

Mountain guns.

While the naval service has been calling for the largest guns we can make, the lightest ordnance has been required for mountain warfare.

In fact, there have been four different patterns of rifled M.L. mountain guns, all 7-prs., the latest of which is the lightest; viz. two of bronze weighing respectively 224 lbs. and 200 lbs., and two of steel, the one for Bhootan weighing 190 lbs., and the other for Abyssinia.

This last pattern, weighing 150 lbs.—only a quarter of the weight of the projectile for the 12″ gun—has been sealed to guide future manufacture.

The Abyssinian gun was designed in the Royal Gun Factories, where the two batteries (12 guns) were manufactured within six weeks of the date of order, from steel blocks furnished at four days notice by Messrs Firth & Co., Sheffield.*

The steel blocks were cast similarly to those used for the steel barrels of Woolwich guns; indeed, the manufacture of the mountain gun is very similar to the preparation of a steel tube, the solid block being bored, toughened in oil, rifled, and turned down to proper size and shape.

The calibre of the gun is 3″; the rifling is a uniform spiral of one turn in 20 calibres; the grooves have angular sides like those of the present

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* Memorandum on the 7-pr, mountain equipment for special service in Abyssinia, by Colonel Wray, C.B., R.A., 1867.

French field gun; for the general dimensions of the gun, the sighting arrangement,* and a section (full size) of the groove see Figs. 12 and 13.

Fig. 12.

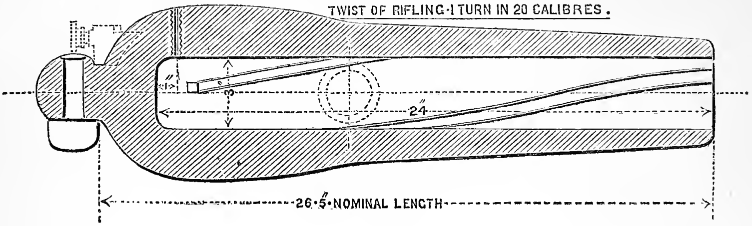
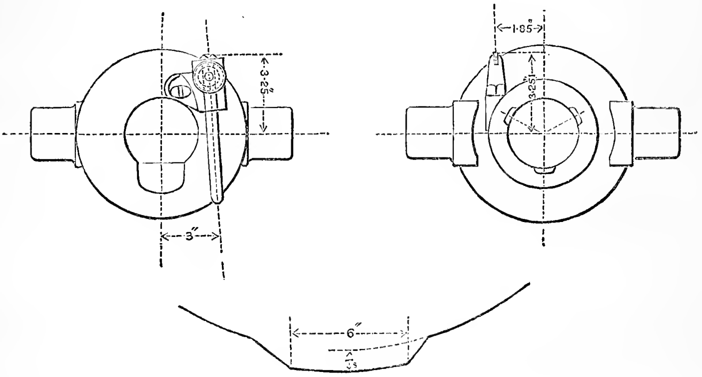


Fig. 13.



With a charge of 6 oz., and with an elevation of 16°, a range of 1000 yards was obtained with a common shell (7 lbs. 7 oz.), and with a charge of 3 oz. and an elevation of 34°, a range of 1150 yards was obtained with double shell (12 lbs.)

The Abyssinian gun-carriage was of steel, and admitted of an elevation of 34° by the removal of the elevating screw.

The projectiles sent to Abyssinia consisted of common shell, double shell, Boxer's shrapnel, and case shot, and a supply of 6-pr. Hale's rockets accompanied each of the batteries.

The mountain batteries in Abyssinia.

The Abyssinian batteries arrived at Zoulla on the Red Sea, early in December, 1867, in charge of Lieutenants Nolan and Chapman, and having been conveyed without damage, through 400 miles of a very mountainous country, they did good service at Magdala on the 10th and 13th of April last.

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* In consequence of some of the sights having been broken off in Abyssinia, new patterns have been approved, and they will be attached to the gun centrally in place of at one side.

The following notes on the subject are, with Colonel Milward's courteous permission, extracted from his diary in Abyssinia.

"We left Antalo on the 12th of March, and on the 10th of April came into action before Magdala. We had a severe and trying march over perhaps the most difficult country that guns could be called upon to traverse.

"The 'A' battery accompanied the advanced guard throughout, often with the pioneer force over ghauts where no touch had been given to the track. Nothing was found too difficult. No serious accident happened, and in no instance was a mule lost, all the loads came safe—no falls—not a sore back. In one instance, ascending the frightful ghaut from the Jeddah to the Talanta plain, where the battery was part of the advance guard, and where the road had been washed away by the torrents, leaving it next to impossible for men in fact, one gun fell over and the front sight was broken; this was the leading gun of the battery, and I sent back 40 pioneers to fill in the worst part of the broken road, which was roughly done in a few minutes, and the remainder of the battery passed over without an accident.

"The success of this battery in marching is most complete, and I think there is no doubt it could accompany infantry anywhere.

"10th April—the fire was well sustained—the guns certainly require wet sponges. The shells burst well, and I am not aware that any were picked up unburst. The following rounds were fired at ranges varying from 450 to 1800 yds.

Shrapnel	55	Case	2
Common	46	Rockets	15

Total ...... 118.

"The recoil in some guns became very violent after a few rounds fired rapidly; the ground was very hard where this occurred.

"On the 13th at Magdala, the following rounds were fired by 'A' battery:—

Common shell	94	Double shell............	15

Rockets 10

"The double shells were fired from wooden mortar beds with 4 oz. charges and carried up to 1400 yds. easily.

"The common shell were fired at 1300 and 1450 yds. and burst uniformly well. The orders were to shell the defences and huts about the gate. The best effect was produced, as the defenders were seen to leave their post, and thus make easy work for the infantry.

"'B' battery fired about the same number of rounds; this battery was not present on the 10th. On the 13th they produced good effect by getting two guns by hand to an almost inaccessible point at the top of Salassi. No shells stuck this day, as water was available, and wet sponges were used occasionally. One gun of 'A' battery was dismounted and taken by hand up the rugged ascent to the gate of Magdala immediately after the assaulting party; this was done by two detachments without great difficulty, and would have been of great value had the service of the gun been necessary to clear the place, filled as it was with houses. This is an important use to which these guns may be applied; the very handy way of packing the ammunition, enabling a supply to be carried with the greatest ease.

"In fact," writes Colonel Milward, "I had no idea so small a gun could be so effective."[*]

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[*] Letter to Captain Stoney, 24/6/68.

Abyssinian steel gun and carriage.

EXPERIMENTS ON FRICTION.

BY

COLONEL H. CLERK, R.A., F.R.S.

Since the introduction of heavy rifled guns into the service, it has become necessary to use powerful compressors to check their recoil.

The following experiments were instituted with a view of ascertaining the best materials of which to make the compressor, and the best mode of applying that material so as to obtain the greatest amount of resistance to the recoil, combined with the least strain upon the carriage or platform.

These experiments were made under the direction of Mr Butter, chief draughtsman of the Royal Carriage Department; and I now forward his account of them for the information of the members of the Royal Artillery Institution.*

They consist of five series :—

(*a*) To ascertain the effect of varying the amount of surface.

(*b*) To ascertain the effect of varying the amount of pressure.

(*c*) To ascertain the effect of varying the number of surfaces.

(*d*) To compare statical and dynamical friction.

(*e*) To obtain coefficients under the same conditions of " rate of motion," and " wear."

In each series various materials were used, such as hard and soft woods. Iron, and gun-metal, in different combinations, viz. wood and wood together, wood with metals, and metals with metals.

The various experiments on friction, as hitherto carried out by Rennie† and others, have been mostly with the view of ascertaining the amount of resistance offered by various machines, &c., to the transmission of force, and have dealt almost exclusively with statical friction, or the resistance offered

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* These experiments were commenced in Oct. 1865, but the pressure of other business has delayed their completion till the present time.

† Vide Phil. Trans. 1829, Rennie " On Friction."

by surfaces *to begin* to slide; while for the purpose of determining data which should guide the construction of breaks or compressors the action of surfaces when held tightly in contact and *during their motion* must be the aim of the experimenter.

From the construction of most compressors and breaks, particularly such as employ wood surfaces, the actual compression of the material is an essential element in their action, in addition to friction and adhesion, while the latter from the violence of the commencement of motion, is of the least possible value.

In order to approximate to the conditions under which compressors act, long tongues or slips of material were pressed between stationary blocks having smaller surfaces, and were set in motion by a blow. The lowest weight which would sustain the motion when once set up gave the value of the resistance.

The blow was used to destroy adhesion, and, as will be seen in the description of the experiments, any increase in the intensity of the blow, beyond that absolutely required to establish motion, did not in the least affect the value of the resistance, merely accelerating the motion during the instant of contact.

Description of the apparatus.

A lithographic press was selected as offering advantages in applying and removing the pressures. The bed and roller were removed, and it was fitted up as shewn in Plate I.

A long lever *c*, resting upon a steel knife-edge fulcrum at *d*, acted with its shorter arm upon the under side of a table *w*, pressing it upward with a pressure proportional to the weight applied at the opposite arm.

The weight of the power arm was composed of the weights, the scale pan, and the lever itself.

On the table the specimens (as *e*, *f*, *e*) were placed; the upward pressure of the lever brought the upper surface in contact with the cross beam *a*, which was capable of being raised or lowered by means of the screw and lever *b*, *r*.

Strong buttresses *h*, and cross pieces *g*, prevented the blocks *e*, *e*, intended to be stationary, from moving when the tongue *f*, was pulled through by means of the chain *i*, the latter being fixed to the pulley *k*.

In order to lessen the number of weights used in drawing the pieces through, a segment of a large wheel *l* was fixed upon the same axle as the pulley, a counterbalance weight *m* being used to prevent its weight influencing the result. The scale pan was attached to the circumference of the segment, as shewn.

To measure the comparative values of the blows used to set up motion, a ball pendulum *o* was used, together with a card board sector *q*.

Dimensions, weights, &c. connected with the apparatus.

Weight of lever *c*, 44·375 lbs.
Length of arms = short, 3 in., long 60 in.
Distance of centre of gravity from fulcrum 29·12 in.

Effective pressure of the lever (acting with its own weight) at W,

$$= \frac{44{\cdot}375 \times 29{\cdot}12}{3} = 420{\cdot}73 \text{ lbs.}$$

Equivalent weight, if applied at the extremity of the long arm,

$$= \frac{430{\cdot}73}{20} = 21{\cdot}536 \text{ lbs,}$$

Weight of small scale pan, &c. 21 lbs.

Total pressure at W, due to $(21 \times 21{\cdot}536)$ acting at the end of long arm,

$$= (21 \times 21{\cdot}536)\ 20 = 850{\cdot}7 \text{ lbs.}$$

Weight to be placed in scale pan, to produce ½ ton pressure at W.

$$= \frac{1120\text{-}850{\cdot}7}{20} = 13{\cdot}5 \text{ lbs.}$$

For every additional ½ ton it was requisite to place ½ cwt. in the scale pan.

Beyond the above, ·55 lb. was needed in the scale pan to balance the weight of table, &c. at W.

The gain of the leverage, ascertained by experimenting with various weights of the segment and pulley arrangements kl, was 4·96 : 1, therefore the weights placed in the large scale pan + the weight of the scale pan, &c. × 4·96 = R in the tables.

Description of the experiments.

SERIES *a.*

TO ASCERTAIN THE EFFECT OF VARYING THE AMOUNT OF SURFACE.

The woods used in this series were English oak, elm, East Indian teak, and yellow pine; the metals were wrought-iron and gun-metal; and the whole were carefully surfaced.

A constant pressure of 2240 lbs. was used throughout, on "two" sliding surfaces; the results are given in Tables I. to VIII., Table VII. being a general summary of the results, and Table VIII. a statement of the condition of the materials after pressures of 140 lbs. and 560 lbs. to the square inch respectively.

From these experiments it appears that the amount of surface has no direct effect on the coefficient of friction of motion, but the small surfaces require a more violent shock to set them in motion; and when the amount of pressure per square inch exceeds 140 lbs. abrasion is liable to commence, and therefore the surfaces of any compressor for a gun carriage should be sufficiently large to allow of the pressure necessary to check the recoil not exceeding 80 to 120 lbs. to the square inch, It appears also from these experiments that when the material drawn through is the same as that through which it is drawn, the results are much more irregular, and the lowest attainable rate, much greater than is the case where different materials are used; the coefficient is also generally greater, but this should be considered with reference to its motion in a given time to get a true estimate of its value. In the case of gun-metal, when drawn through other materials it gave the most uniform results and lowest rates—about one inch per minute—but when drawn through gun-metal, its motion increased to 30 and 20 inches per minute, and was so irregular as to be in one instance only 1¼ inches per minute. This probably arises from cohesion being more readily set up between the surfaces of similar, than between those of dissimilar materials.

It will be seen that there is not much difference in value between the coefficients derived from the use of various materials—especially after use, as the surfaces appear to rub down to a uniform condition after two or three trials.

	For two surfaces.	Mean rate, inches per minute.
Wood through wood :—		
The woods in different combinations, except pine, gave a uniformly regular coefficient of	·350	30
Wood through metals :—		
Woods through wrought-iron gave a coefficient of	·271	1·6
〃 〃 gun-metal 〃 〃	·264	0·9
Metals through woods :—		
Gun-metal, through woods, except teak, gave......	·347	2·8
Wrought-iron 〃 〃	·294	4·0
Metals through metals :—		
Gun-metal, through iron, gave coefficient	·390	0·33
Iron through gun-metal 〃 〃	·400	0·33
Iron through iron 〃 〃	·545	27·0
Gun-metal through gun-metal 〃	·697	17·0

SERIES *b*.

TO ASCERTAIN THE EFFECT OF VARYING THE PRESSURE ON THE SAME EXTENT OF SURFACE.

The materials used were the same as in Series *a*, except elm, pine, and gun-metal, which were omitted, and ground iron, which was added.

The bearing surface was in all cases 32 square inches, and the pressure varied from 0·5 to 2·5 tons.

The results are given in Tables IX. to XVII.; Table XVII. being a general summary.

Making allowance for the effect produced by repeated use, it appears from this series that the resistance varies directly as the pressures. In some cases it is a little more, and in others a little less, than this proportion; just as they increase or diminish their resistance from use.

SERIES *c*.

TO ASCERTAIN THE EFFECT OF VARYING THE NUMBER OF SURFACES WITH A CONSTANT PRESSURE.

The materials used were the same as those in Series *b*. The area of the bearing surface was also, in all cases, 32 square inches, and the pressure was maintained at ½ ton.

The results are given in Tables XVIII. to XXVI; the latter being the general summary.

From this series the important fact is ascertained that with a constant pressure the resistance of friction varies directly as the number of sliding surfaces upon which the pressure acts; thus with one piece moving there are two sliding surfaces, and calling the resistance a, this resistance will be $2a$ for two moving pieces, $3a$ for three, and so on, although the pressure is unvarying.

It is to this principle that the various forms of the American compressor owe their value, and by its application the pressure and consequent strain may be kept low, while the resistance may be increased to any extent whatever, by simply increasing the number of sliding surfaces.

SERIES *d*.

TO ASCERTAIN, WITH A VARYING PRESSURE AND USING NO BLOW, THE VALUE OF THE FRICTION OF "REST," IN ORDER TO COMPARE WITH THAT OF "MOTION," IN SERIES *b*.

The materials used were iron, surfaced and ground, and oak.

The bearing surface was 32 square inches, as in Series *b* and *c*, and the pressure varied from 0·5 to 2·5 tons, as in Series *b*.

The results are tabulated in Tables XXVII. to XXXIII. inclusive; Table XXXII. being a general summary, and Table XXXIII. a comparison with Series *b* (from Table XVII).

It appears from these experiments that when motion was induced without a jar, the resistance was greatly increased, owing to cohesion setting in, but when once the weight in the scale pan was sufficient to destroy the cohesion the piece ran through in a much less time (⅓ to ⅛th); wrought-iron through wrought-iron (surfaced) was, however, an exception, there being in this instance no practical difference between the friction of rest and motion; while ground iron through ground iron gave the greatest difference.

SERIES *e*.

This series was undertaken with the view of obtaining coefficients which would more strictly compare with one another than do those in the foregoing experiments, where the conditions influencing the results were found to be not identical, more especially—

The effect of continued use.
The variation of rate of motion.

With respect to the 1st, the experiments were conducted so as to give the coefficients for each pressure under the same conditions of use; thus in the 1st trial the pieces were passed through under a ½ ton pressure (the lightest pressure) and were not again used under this pressure until the 10th trial. In the 2nd trial they were subjected to a pressure of 2½ tons (the heaviest pressure), which was repeated in the 9th trial, and so on with the other pressures; the mean coefficients arrived at in the summary being the means of the two series at the same pressure.

With regard to the second influence referred to, the rates were varied under each pressure; the results given in the tables being in all cases the means of several. By this method a tolerable uniformity is arrived at in the rates at different pressures; and a juster comparison may be made between them.

The materials used were wrought-iron, ground and surfaced, gun metal, also ground and surfaced, and teak.

From this series it appears that the resistance of friction increases as the surface becomes condensed with use; that varying the pressure has no effect on the coefficient, and that when the rate is uniform there is little difference in the value of the coefficients of the materials tried.

The following are the mean coefficients at the lowest and highest common rates, viz. 3 ins. and 20 ins. per minute (two sliding surfaces):—

	Common rates.	
	Lowest=3″.	Highest=20″.
Teak through surfaced iron	·369	·552.
Ground gun-metal, through ground iron	·416	·471.
Surfaced 〃 surfaced 〃	·429	·514.
Ground iron through ground iron	·402	·502.

The following are the mean coefficients at the lowest and highest common rates, viz. 0·25 ins. and 30 ins. per minute, omitting ground iron through ground iron, which was incapable of giving the lowest rate:—

	Common rates.	
	Lowest=¼″	Highest=30″
Teak through surfaced iron	·270	·655
Ground gun-metal through ground iron	·352	·525
Surfaced 〃 surfaced 〃	·346	·537

The results are given in Tables XXXIV. to XXXVIII.

The mean values of the coefficients of each material at various rates of motion are stated in Table XXXVIII. and the curves due to them are drawn in Fig. 1, Plate II. A general mean of all the coefficients is given in Table XXXIX., from which a single fair curve is obtained, Fig. 2, Plate II.

From this fair curve a table of variations is made, due to a rate of 8 inches per minute (Table XL.) by means of which, assuming that the fair curve represents generally the variations of all coefficients at different rates of motion, the coefficients of Series *a* may be reduced to a common rate of motion, for the purpose of obtaining a stricter comparison.

This is done in Table XLI. and the diagram, Plate III. represents their relative values, the shaded part being the mean coefficient of the different surfaces.

General remarks on the experiments.

For the following reasons it is considered that the blow did no more than destroy the adhesion which the pressure set up between the surfaces:—

1st. If there were not sufficient weight to overcome the friction of motion; when the piece was struck, it moved through a space proportional to the force of the blow (varying from $\frac{1}{8}$th to $\frac{1}{100}$th of an inch) and came to a dead stop.

2nd. When the proper drawing-through weight was reached, the piece continued to move at a higher or lower rate of motion according to the nature of the surfaces.

3rd. If the blow were increased beyond that absolutely needed to break the contact of the surfaces, it simply had the effect of driving the piece a little more during the instant of impact; the rate of the continuous motion being unaffected by it.

The blow therefore corresponded, although in a much smaller degree, with the violent shock which is felt in the first instant of discharge throughout the carriage and platform, and which must result in effectually destroying any force of adhesion between the surfaces of the compressor; hence the frictional resistance of the compressor during recoil, and of the specimens while in motion were developed as nearly as possible under the same conditions, both being comparatively free of the force of adhesion.

The force of the blow needed to establish motion was found to vary with different materials, and was not required at all in the case of some—notably gun-metal and iron—the natural inference from this is that some surfaces are less disposed than others to adhere or lock into one another, especially as in all cases where the surfaces in contact were of the same material, and therefore of the same molecular construction, the cohesion was greatest and needed the greater blow to destroy it and set up motion; and where dissimilar materials were employed, the blow was of diminished force, or not needed at all, and hence the tendency to adhesion was less or had not begun to develope itself.

It was noticed that the tendency of some surfaces to cohere was so great that it was not possible to keep up a uniform continuous slow motion. Sufficient weight was needed in the scale pan to make the piece move with a certain velocity before adhesion could be fairly overcome, hence the surfaces which had no tendency to adhere, as metal and iron, would slide with so low a weight that the motion was almost imperceptible, while in the case of others, as oak and oak, cohesion could not be overcome until such weight was in the scale pan as produced high rates of motion.

The resistance of friction as proved by M. Morin,* no doubt is independent of the rate of motion and depends on the space passed over, and in the higher rates of motion the weight in the scale pan was in excess of that absolutely needed by friction alone, and therefore expended itself in doing the work in a shorter time. Such weights, therefore, cannot be taken as giving true comparative values of the resistance of friction of the various substances, and the coefficients worked out from them cannot strictly compare unless the rates are identical.

The whole of the experiments demonstrate that it is quite impossible to ensure constant results, because it is impossible to control all the conditions producing such results; the variation is, however, greater in some than in others.

There is no doubt that the principal cause of the variation is the fact that after passing over each other under heavy pressure the surfaces change from their normal state, and when they slide past each other a second time they do so under new conditions; different parts are brought in contact, and certain raised portions of the surfaces are more condensed. So much is this the case, that it was found the progressive variations due to continued use were so great as to prevent the effects of different pressures from being distinguished. To partially obviate this and other sources of error (as varying rates), Series *e* was arranged and carried out. To use fresh specimens in place of repeatedly using the same would, as was found, import greater variations in the results.

The velocities with which the surfaces of compressors slide past each other during the recoil of the gun are so much greater than the highest rate attained by the specimens under trial, that, as in the case of the specimens, adhesion was overcome at either high or low rates; therefore in the quicker movement of compressor plates there can be no retarding effect from this force, except during the first and last instants, unless, probably, much greater pressures per square inch are applied than was the case in the experiments; but this is not so in any compressors at present in use; the Elswick pattern producing, with 100 lbs. on the lever, about 80 lbs. per square inch, while a pressure of 175 lbs. was used in the experiments.

The manner in which the various specimens passed through the others was very different.

Smooth regular motions always resulted from the pieces capable of giving low rates, and the resulting coefficients were more uniform, while also the period at which adhesion ceased, and the blow no longer required, was tolerably well marked.

On the other hand the specimens incapable of yielding the low rates of motion passed along with a jerky and irregular motion, causing much vibration in the apparatus, and great variation in the resulting coefficients. The point at which the blow ceased to be required was also very irregularly marked.

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* "Nouvelles Experiences sur le Frottement." M. Morin. Paris 1833.

Dissimilar materials in contact gave uniformly the slow uniform results; especially teak and iron, and metal and iron.

Similar materials in contact gave the unsteady, irregular results, more particularly iron and iron.

Summary of results.

1. From a variety of causes the frictional resistance of any combination of materials is so variable, that no absolute value for the coefficient can be given.

2. That similar materials in contact are more irregular and jerky than dissimilar ones.

3. That a pressure of 140 lbs. on the square inch can be used without incurring abrasion of the surfaces, while 560 lbs. on the square inch injures most of them.

4. That varying the extent of surface has no practical effect on the value of the coefficient.

5. That the frictional resistance varies directly as the total pressure up to the point at which adhesion sets in.

6. That the frictional resistance varies directly as the number of surfaces acted upon by the pressure.

7. That the highest coefficient is obtained with gun-metal and gun-metal, but the motion is irregular and violent, whereas gun-metal and iron, while giving nearly as high a coefficient, give a very slow and regular motion.

8. That as respects compressors for gun carriages, the experiments appear to establish the following facts :—

(1) That the materials used for the rubbing surfaces should be dissimilar, gun-metal and wrought-iron being the most suitable.

(2) That the best pressure per square inch is from 80 to 120 lbs., and any resistance required beyond this should be obtained by increasing the number of surfaces in preference to increasing the pressure.

Description of the Plates.

Plate I. Sketch shewing the general arrangement of the apparatus and mode of conducting the experiment.

Plate II. (Fig. 1). Curves, shewing the effect of varying the rate of motion with different materials, under a mean pressure of 1·5 tons. (Fig. 2) mean of the curves shewn in Fig. 1 with fair curve.

Plate III. Diagram, shewing the coefficients of Series *a* at a common rate of motion of 8 inches per minute.

SERIES *a*. TABLE I.

EFFECT OF USING DIFFERENT NATURES AND AMOUNTS OF SURFACES UNDER A CONSTANT PRESSURE OF ONE TON. $P=2240$ lb., $b=3$ lb., r radius of $b=20''$.

TWO SURFACES. THROUGH OAK.

Number of experiment.		Nature of material.	S, amount of surface.	P, pressure per square inch $=\frac{P}{S}$	R,*wt. to overcome friction of motion.		C, coeff. of friction of motion $=\frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.	Remarks.
					For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.		
			in.	lbs.	lbs.	lbs.		°	ft. per sec		
1	1 2 3	Oak through oak.	64	35	868 878 868	871	·388	30	3·79	20	Motion slightly irregular.
2	1 2 3		32	70	764 739 774	759	·339	30	3·79	36	Motion regular.
3	1 2 3		16	140	730 694 730	718	·320	75	8·92	180	The pressure appears to produce cohesion, hence the large impact to establish motion.
4	1 2 3		4	560	720 671 643	690	·312	52·5	6·49	...	Very quick and irregular.
	4				727	...	...	...	...	...	Grain slightly scored.
5	1 2 3	Elm through oak.	64	35	902 936 936	924	·412	30	3·79	10	Motion regular.
6	1 2 3		32	70	798 794 798	797	·356	30	3·79	25	Motion regular.
7	1 2 3		16	140	765 694 730	730	·326	75	8·92	160	Same as No. 3 experiment.
8	1 2 3		4	560	676 642 652	657	·293	30	3·79	14	Elm compressed, oak slightly scored.
9	1 2 3	Teak through oak.	64	35	957 937 947	947	·422	30	3·79	2·8	Motion regular.
10	1 2 3		32	70	764 729 784	759	·339	30	3·79	16	Motion regular.
11	1 2 3		16	140	740 730 720	730	·326	75	8·92	36	Same as No. 3 experiment.
12	1 2 3		4	560	661 686 663	670	·299	30	3·79	25	Teak compressed, oak scored.
13	1 2 3	Pine through oak.	64	35	1076 1066 1052	1065	·475	30	3·79	6	Motion regular.
14	1 2 3		32	70	967 937 937	947	·423	30	3·79	18	Motion regular.
15	1 2 3		16	140	1077 1042 1181	1100	·491	75	8·92	40	Same as No. 3 experiment.

* By "friction of motion" is meant friction with impact.

TWO SURFACES. THROUGH OAK.

Table I.—*Continued.*

Number of experiment.		Nature of material.	S, amount of surface.	P, pressure per square inch $= \frac{P}{S}$	R, wt. to overcome friction of motion.		C, coeff. of friction of motion $= \frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.	Remarks.
					For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.		
			in.	lbs.	lbs.	lbs.		°	ft. per sec		
16	1		4	560	2343	...	...	...		...	Fir surface destroyed, oak scored.
17	1	Iron through oak.			625						
	2		64	35	590	605	·270	30	3·79	6	Motion regular.
	3				600						
18	1				660						
	2		32	70	704	689	·307	30	3·79	6	Motion regular.
	3				704						
19	1				715						
	2		16	140	740	728	·325	75	8·92	6	Slightly jerky.
	3				730						
20	1				700						
	2		4	560	728	714	·318	52·5	6·49	12	Wood greatly compressed and polished.
	3				728						
	4				700						
21	1	Gun-metal through oak.			729						
	2		64	35	749	739	·329	30	3·79	3·3	Regular.
	3				739						
22	1				729						
	2		32	70	679	699	·312	30	3·79	5	Regular.
	3				689						
23	1				879						
	2		16	140	869	870	·388	75	8·92	0·75	Slightly jerky.
	3				864						
24	1				840						
	2		4	560	870	847	·378	45	5·61	6	Wood compressed and polished.
	3				840						
	4				840						

TWO SURFACES. THROUGH ELM.

Table II.

Number of experiment.		Nature of material.	S, amount of surface.	P, pressure per square inch	R for each expmt.	R mean.	C	A	V	M	Remarks.
25	1	Oak through elm.			863						
	2		64	35	863	853	·380	30	3·79	15	Regular.
	3				833						
26	1				799						
	2		32	70	799	796	·351	30	3·79	30	Accelerated motion.
	3				789						
27	1				799						
	2		16	140	819	809	·361	75	8·92	60	Very jerky. Same as No. 3 experiment.
	3				809						
28	1		4	560	1510	...	...	...	...	...	Oak scored, elm indented and scraped to depth of ·03″.
29	1	Elm through elm.			937						
	2		64	35	903	907	·405	30	3·79	9	Regular.
	3				888						
30	1				799						
	2		32	70	784	782	·349	30	3·79	17	Accelerated motion.
	3				764						
31	1				679						
	2		16	140	739	699	·312	75	8·92	73	Same as No. 3 experiment.
	3				679						
32	1		4	560	1960	...	...	...	...	...	Elm scraped upon all its surfaces.
33	1	Teak through elm.			1076						
	2		64	35	1061	1069	·477	30	3·79	2·4	Regular.
	3				1071						
34	1				834						
	2		32	70	799	809	·361	30	3·79	12	Accelerated motion.
	3				794						
35	1				765						
	2		16	140	749	748	·334	75	8·92	30	Same as No. 3 experiment.
	3				729						
36	1				607						
	2		4	560	613	604	·270	30	3·79	20	Elm slightly scored, teak perfect.
	3				592						

TWO SURFACES. **TABLE II.**—*Continued.* THROUGH ELM.

Number of experiment.		Nature of material.	S, amount of surface.	P, pressure per square inch $= \frac{P}{S}$	R, wt. to overcome friction of motion.		C, coeff. of friction of motion $= \frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.	Remarks.
					For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.		
			in.	lbs.	lbs.	lbs.		°	ft. per sec		
37	1	Pine through elm.	64	35	1215	1195	·533	30	3·79	9	Regular.
	2				1180						
	3				1190						
38	1		32	70	1008	988	·441	30	3·79	18	Regular.
	2				973						
	3				983						
39	1		16	140	1200	1150	·513	75	8·92	32	Same as No. 3 experiment.
	2				1190						
	3				1061						
40	1		4	560	1510	...	...	...	...	...	Elm much scored, pine destroyed.
41	1	Wrought-iron through elm.	64	35	601	603	·270	30	3·79	0·9	Regular.
	2				606						
	3				601						
42	1		32	70	730	717	·320	30	3·79	3·4	Regular.
	2				715						
	3				705						
43	1		16	140	625	620	·276	30	3·79	4·4	Regular.
	2				620						
	3				615						
44	1		4	560	851	851	·380	30	3·79	10	Elm slightly compressed.
	2				851						
	3				851						
45	1	Gun-metal through elm.	64	35	720	700	·312	0	0	0·5	Regular.
	2				700						
	3				680						
46	1		32	70	765	752	·335	0	0	4·3	Regular.
	2				750						
	3				740						
47	1		16	140	785	775	·346	0	0	0·5	Regular.
	2				765						
	3				775						
48	1		4	560	954	972	·438	0	0	11	Elm slightly compressed.
	2				989						
	3				974						

TWO SURFACES. **TABLE III.** THROUGH TEAK.

49	1	Oak through teak.	64	35	869	856	·382	30	3·79	6	Regular.
	2				859						
	3				839						
50	1		32	70	799	780	·348	30	3·79	8	Regular.
	2				775						
	3				765						
51	1		16	140	720	710	·317	75	8·92	17	Same as No. 3 experiment.
	2				710						
	3				700						
52	1		4	560	677	675	·301	30	3·79	4	Regular,
	2				677						
	3				672						
53	1	Elm through teak.	64	35	760	776	·346	30	3·79	2·3	Regular.
	2				770						
	3				799						
54	1		32	70	775	763	·340	30	3·79	6	Regular.
	2				760						
	3				755						
55	1		16	140	694	694	·310	75	8·92	13	Same as No. 3 experiment.
	2				684						
	3				704						
56	1		4	560	712	690	·308	30	3·79	6	Regular.
	2				705						
	3				653						

TWO SURFACES. TABLE III.—*Continued.* THROUGH TEAK.

Number of experiment.		Nature of material.	S, amount of surface.	P, pressure per square inch $= \frac{P}{S}$	R, wt. to overcome friction of motion.		C, coeffi. of friction of motion $= \frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.	Remarks.
					For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.		
			lbs.	lbs.	lbs.	lbs.		°	ft. per sec		
57	1 2 3	Teak through teak.	64	35	1077 1067 1057	1067	·476	30	3·79	4	Regular.
58	1 2 3		32	70	859 844 834	846	·380	30	3·79	9	Regular.
59	1 2 3		16	140	780 765 760	768	·343	75	8·92	12·6	Regular.
60	1 2 3		4	560	672 672 670	671	·300	30	3·79	9	Regular.
61	1 2 3	Pine through teak.	64	35	1149 1114 1124	1129	·504	30	3·79	5	Regular.
62	1 2 3		32	70	971 966 961	966	·431	30	3·79	12	Regular.
63	1 2 3		16	140	1129 1124 1114	1122	·500	75	8·92	38	Regular.
64	1		4	560	1232	...	...	...	...	...	Fir destroyed, teak scored.
65	1 2 3	Wrought-iron through teak.	64	35	625 590 635	617	·275	30	3·79	1·6	Regular.
66	1 2 3		32	70	645 645 679	656	·337	30	3·79	2	Regular.
67	1 2 3		16	140	565 555 560	560	·250	30	3·79	3	Regular.
68	1 2 3		4	560	591 616 644	617	·275	30	3·79	4	Regular.
69	1 2 3	Gun-metal through teak.	64	35	625 645 590	620	·280	30	3·79	0·5	Regular.
70	1 2 3		32	70	645 590 565	600	·270	30	3·79	0·8	Regular.
71	1 2 3		16	140	540 540 535	538	·240	30	3·79	0·5	Regular.
72	1 2 3		4	560	592 592 602	595	·265	30	3·79	0·5	Regular.

TWO SURFACES. TABLE IV. THROUGH PINE.

73	1 2 3	Oak through pine.	64	35	1249 1214 1199	1221	·545	30	3·79	13	Regular.
74	1 2 3		32	70	1027 1042 1042	1037	·463	30	3·79	17	Regular.
75	1 2 3		16	140	1269 1249 1234	1251	·563	75	8·92	60	Regular.
76	1 2 3		4	560	885 921 885	897	·400	30	3·79	33	Pine compressed ·05″.

TWO SURFACES. TABLE IV.—*Continued.* THROUGH PINE.

Number of experiment.		Nature of material.	S, amount of surface.	P, pressure per square inch $=\frac{P}{S}$	R, wt. to overcome friction of motion.		C, coeffi. of friction of motion $=\frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.	Remarks.
					For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.		
			in.	lbs.	lbs.	lbs.		°	ft. per sec		
77	1 2 3	Elm through pine.	64	35	1169 1159 1149	1159	·517	30	3·79	12	Regular.
78	1 2 3		32	70	1008 1033 1018	1020	·450	30	3·79	16	Regular.
79	1 2 3		16	140	1110 1105 1105	1107	·494	75	8·92	30	Regular.
80	1 2 3		4	560	885 870 905	883	·394	30	3·79	30	Pine compressed ·05″.
81	1 2 3	Teak through pine.	64	35	1077 1042 1062	1060	·473	30	3·79	6	Regular.
82	1 2 3		32	70	1027 1007 997	1010	·451	30	3·79	12	Regular.
83	1 2 3		16	140	1110 1095 1095	1100	·492	75	8·92	30	Regular.
84	1 2 3		4	560	885 880 885	883	·394	30	3·79	40	Pine compressed ·05″.
85	1 2 3	Pine through pine.	64	35	1214 1244 1214	1224	·546	30	3·79	11	Regular.
86	1 2 3		32	70	1097 1077 1087	1087	·485	30	3·79	15	Regular.
87	1 2 3		16	140	1199 1194 1194	1196	·534	75	8·92	60	Regular.
88	1		4	560	2336	...	...	...	...	...	All surfaces destroyed.
89	1 2 3	Wrought-iron through pine.	64	35	659 625 645	643	·287	30	3·79	2·1	Regular.
90	1 2 3		32	70	635 650 635	640	·286	30	3·79	2·8	Regular.
91	1 2 3		16	140	575 600 575	583	·260	30	3·79	3·5	Regular.
92	1 2 3		4	560	626 607 630	621	·277	30	3·79	3·5	Pine compressed ·05″.
93	1 2 3	Gun-metal through pine.	64	35	819 829 824	824	·368	30	3·79	0·5	Regular.
94	1 2 3		32	70	694 689 679	687	·307	30	3·79	0·7	Regular.
95	1 2 3		16	140	679 659 669	669	·298	30	3·79	0·7	Regular.
96	1 2 3		4	560	782 801 811	798	·356	30	3·79	0·5	Pine compressed ·03″.

TWO SURFACES.

TABLE V.

THROUGH WROUGHT-IRON.

Number of experiment.		Nature of material.	*S*, amount of surface.	*P*, pressure per square inch $= \frac{P}{S}$	*R*, wt. to overcome friction of motion.		*C*, coeffi. of friction of motion $= \frac{R}{P}$	*I*, impact of *b*.		*M*, motion of the piece drawn through in inches per minute.	Remarks.
					For each expmt.	Mean.		*A*, mean angular fall of *b*.	*V*, velocity of *b*.		
			in.	lbs.	lbs.	lbs.		°	ft. per sec		
97	1 2 3	Oak through W.I.	64	35	755 755 783	764	·341	30	3·79	1·25	Regular.
98	1 2 3		32	70	694 659 679	677	·302	30	3·79	4·5	Regular.
99	1 2 3		16	140	520 510 500	510	·228	0	0	1·8	Regular.
100	1		4	560	781	781	·349	30	3·79	...	Started with 781 lbs., the oak surface then scraped up and 954 lbs. were required.
101	1 2 3	Elm through W.I.	64	35	635 625 645	635	·283	30	3·79	·88	Regular.
102	1 2 3		32	70	620 630 640	630	·281	30	3·79	2	Regular.
103	1 2 3		16	140	441 466 426	444	·198	0	0	1·25	Regular.
104	1		4	560	677	677	·302	30	3·79	...	Surfaces of elm scraped up.
105	1 2 3	Teak through W.I.	64	35	635 625 615	625	·279	30	3·79	1·13	Regular.
106	1 2 3		32	70	555 540 550	548	·245	30	3·79	1·5	Regular.
107	1 2 3		16	140	451 446 451	449	·200	0	0	1·4	Regular.
108	1		4	560	506 506 526	513	·229	30	3·79	3	Surfaces of teak slightly scraped.
109	1 2 3	Pine through W.I.	64	35	625 615 650	630	·281	30	3·79	1	Regular.
110	1 2 3		32	70	595 585 605	595	·266	30	3·79	1·6	Regular.
111	1 2 3		16	140	625 615 610	617	·276	0	0	1	Regular.
112	1		4	560	1200	...	...	...	...	...	Surfaces of pine destroyed.
113	1 2 3	W.I. through W.I.	64	35	1423 1458 1491	1457	·650	30	3·79	30	Very irregular and jerky.
114	1 2 3		32	70	1042 1067 1067	1059	·481	30	3·79	40	Very irregular and jerky.
115	1 2 3		16	140	1042 1077 1110	1076	·480	30	3·79	12	Very irregular and jerky.
116	1 2 3		4	560	1259 1307 1259	1275	·568	23	2·92	...	Very irregular and jerky.

TWO SURFACES. THROUGH W.I.

TABLE V.—*Continued.*

Number of experiment.		Nature of material.	S, amount of surface.	P, pressure per square inch $=\frac{P}{S}$	R, wt. to overcome friction of motion.		C, coeffi. of friction of motion $=\frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.	Remarks.
					For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.		
			in.	lbs.	lbs.	lbs.		°	ft. per sec		
117	1	Gun-metal through W.I.	64	35	936	936	·418	30	3·79	0·37	Regular.
	2				926						
	3				946						
118	1		32	70	844	839	·375	30	3·79	0·25	Regular.
	2				834						
	3				839						
119	1		16	140	819	809	·361	30	3·79	0·25	Regular.
	2				809						
	3				799						
120	1		4	560	895	916	·408	0	0	0·44	Motion very regular.
	2				895						
	3				923						
	4				951						

TABLE VI.

TWO SURFACES. THROUGH GUN-METAL.

121	1	Oak thro' gun-metal.	64	35	659	646	·288	0	0	0·8	Regular.
	2				645						
	3				635						
122	1		32	70	655	618	·276	0	0	1·13	Regular.
	2				635						
	3				565						
123	1		16	140	590	573	·256	0	0	0·8	Regular.
	2				570						
	3				560						
124	1		4	560	2688	...	...	...	...	...	Surfaces of oak scraped to depth of ·03″.
125	1	Elm thro' gun-metal.	64	35	590	600	·268	0	0	0·37	Regular.
	2				600						
	3				610						
126	1		32	70	520	515	·230	0	0	0·8	Regular.
	2				510						
	3				515						
127	1		16	140	417	409	·182	0	0	0·63	Regular.
	2				407						
	3				402						
128	1		4	560	2898	...	...	...	...	...	Surfaces of elm scraped to depth of ·05″.
129	1	Teak through gun-metal.	64	35	486	486	·217	0	0	0·37	Regular.
	2				486						
	3				486						
130	1		32	70	467	454	·203	0	0	0·7	Regular.
	2				452						
	3				442						
131	1		16	140	540	537	·239	0	0	0·37	Regular.
	2				530						
	3				540						
132	1		4	560	884	780	·348	30	3·79	4	In 3rd trial, teak scraped to depth of ·08″.
	2				677						
	3										

Table VI.—*Continued.*

TWO SURFACES. THROUGH GUN-METAL.

Number of experiment.		Nature of material.	P, amount of pressure.	p, pressure per square inch $= \frac{P}{S}$	R. wt. to overcome friction of motion.		C, coeff. of friction of motion $= \frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.	Remarks.
					For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.		
			in.	lbs.	lbs.	lbs.		°	ft. per sec		
133	1 2 3	Pine through gun-metal.	64	35	834 824 814	824	·368	30	3·79	0·63	Regular.
134	1 2 3		32	70	659 625 645	643	·287	30	3·79	1·17	Regular.
135	1 2 3		16	140	580 570 560	570	·255	0	0	0·7	Regular.
136	1		4	560	1510 to 1926		...	...	...	...	Surfaces of pine destroyed.
137	1 2 3	W.I. through gun-metal.	64	35	889 879 869	879	·393	0	0	0·21	Regular.
138	1 2 3		32	70	884 869 859	871	·388	30	3·79	0·21	Regular.
139	1 2 3		16	140	869 879 899	882	·393	0	0	0·14	Regular.
140	1 2 3 4		4	560	979 951 923 979	958	·428	0	0	0·75	Regular.
141	1 2 3	Gun-metal thro' gun-metal.	64	35	1724 1744 1719	1729	·771	30	3·79	30	Regular.
142	1 2 3		32	70	1427 1491 1561	1495	·660	30	3·79	1·25	Regular.
143	1 2 3		16	140	1491 1839 2042	1791	·800	0	0	20	Irregular.
144	1 2 3 4		4	560	1259 1147 1203 1371	1245	·556	0	0	...	Motion irregular and jerky.

TABLE VII.

GENERAL SUMMARY OF SERIES *a*, ONE TON PRESSURE, FOR TWO SURFACES.

Material through which drawn.	Oak.				Elm.				Teak.			
	Surface.				Surface.				Surface.			
	64″	32″	16″	4″	64″	32″	16″	4″	64″	32″	16″	4″
OAK :—												
Mean value of *R*, lbs....	871	759	718	690	924	797	730	657	947	759	730	670
Coefficient	·388	·339	·320	·312	·412	·356	·326	·293	·422	·339	·326	·299
Motion per minute, ins.	20	36	180	—	10	25	160	14	2·8	16	36	25
ELM :—												
Mean value of *R*, lbs....	853	796	809	—	907	782	699	—	1069	809	748	604
Coefficient	·380	·351	·361	—	·405	·349	·312	—	·477	·361	·334	·270
Motion per minute, ins.	15	30	60	—	9	17	73	—	2·4	12	30	20
TEAK :—												
Mean value of *R*, lbs....	856	780	710	675	776	763	694	690	1067	846	768	671
Coefficient	·382	·348	·317	·301	·346	·340	·310	·308	·476	·380	·343	·300
Motion per minute, ins.	6	8	17	4	2·3	6	13	6	4	9	12·6	9
PINE :—												
Mean value of *R*, lbs....	1221	1037	1251	897	1159	1020	1107	883	1060	1010	1100	883
Coefficient	·545	·463	·563	·400	·517	·450	·494	·394	·473	·451	·492	·394
Motion per minute, ins.	13	17	60	33	12	16	30	30	6	12	30	40
WROUGHT IRON :—												
Mean value of *R*, lbs....	764	677	510	781	635	630	444	677	625	548	449	513
Coefficient	·341	·302	·228	·349	·283	·281	·198	·302	·279	·245	·200	·229
Motion per minute, ins.	1·25	4·5	1·8	—	0·88	0·2	1·25	—	1·13	1·5	1·4	3
GUN METAL :—												
Mean value of *R*, lbs....	646	618	573	—	600	515	409	—	486	454	537	780
Coefficient	·288	·276	·256	—	·268	·230	·182	—	·217	·203	·239	·348
Motion per minute, ins.	0·8	1·13	0·8	—	0·37	0·8	0·63	—	0·37	0·7	0·37	4
OAK :—	Pine.				Wrought-iron.				Gun-metal.			
Mean value of *R*, lbs....	1065	947	1100	—	605	689	728	714	739	699	870	847
Coefficient	·475	·423	·491	—	·270	·307	·325	·318	·329	·312	·388	·378
Motion per minute, ins.	6	18	40	—	6	6	6	12	3·3	5	0·75	6
ELM :—												
Mean value of *R*, lbs....	1195	988	1150	—	603	717	620	851	700	752	775	972
Coefficient	·533	·441	·513	—	·270	·320	·276	·380	·312	·335	·346	·438
Motion per minute, ins.	9	18	32	—	0·9	3·4	4·4	10	0·5	4·3	0·5	11
TEAK :—												
Mean value of *R*, lbs....	1129	966	1122	—	617	656	560	617	620	600	538	595
Coefficient	·504	·431	·500	—	·275	·337	·250	·275	·280	270	·240	·265
Motion per minute, ins.	5	12	38	—	1·6	2	3	4	0·5	0·8	0·5	0·5
PINE :—												
Mean value of *R*, lbs....	1224	1087	1196	—	643	640	583	621	824	687	669	798
Coefficient	·546	·485	·534	—	·287	·286	·260	·277	·368	·307	·298	·356
Motion per minute, ins.	11	15	60	—	2·1	2·8	3·5	3·5	0·5	0·7	0·7	0·5
WROUGHT IRON :—												
Mean value of *R*, lbs....	630	595	617	—	1457	1059	1076	1275	936	839	809	916
Coefficient	·281	·266	·276	—	·650	·481	·480	·568	·418	·375	·361	·408
Motion per minute, ins.	1·0	1·6	1·0	—	30	40	12	—	0·37	0·25	0·25	0·44
GUN METAL :—												
Mean value of *R*, lbs....	824	643	570	—	879	871	882	958	1729	1495	1791	1245
Coefficient	·368	·287	·255	—	·393	·388	·393	·428	·771	·660	·800	·556
Motion per minute, ins.	0·63	1·17	0·7	—	0·21	0·21	0·14	0·75	30	1·25	20	—

Table VIII.

EFFECT ON MATERIALS UNDER THE PRESSURE OF 560 lbs. TO THE SQUARE INCH.

Number of experiment.	Nature of materials.		Condition after experiment.
4	Through oak.	Oak	Grain slightly scored, irregular motion
8		Elm	Elm compressed, oak slightly scored
12		Teak	Teak do, oak do
16		Pine	Pine grain torn up, oak do
20		W. iron	Oak compressed and polished
24		G. metal	do do do
28	Through elm.	Oak	Oak scored, elm indented and scraped to depth of ·03″
32		Elm	Elm scraped up on both pieces
36		Teak	〃 slightly scraped, teak perfect
40		Pine	〃 much scored, pine torn up
44		W. iron	〃 slightly compressed
48		G. metal	do do do
52	Through teak.	Oak	All surfaces perfect, motion regular.
56		Elm	do do do
60		Teak	do do de
64		Pine	Teak scored, pine torn up
68		W. iron	All surfaces perfect
72		G. metal	do do
76	Through pine.	Oak	Pine compressed ·08″
80		Elm	〃 〃 ·05″
84		Teak	〃 〃 ·05″
88		Pine	All surfaces torn up
92		W. iron	Pine compressed ·05″
96		G. metal	〃 〃 ·03″
100	Through W.I.	Oak	Motion commenced with 781 lbs. the oak surface then scraped up, and 954 lbs. barely sustained motion
104		Elm	Elm surfaces scraped up
108		Teak	Teak surfaces slightly do
112		Pine	Pine surfaces very much scraped
116		W. iron	Motion irregular and jerky
120		G. metal	Motion very regular
124	Thro' G. metal.	Oak	Oak surfaces scraped
128		Elm	Elm do do
132		Teak	Teak do do
136		Pine	Pine do, very much do
140		W. iron	Motion very regular
144		G. metal	〃 irregular and jerky

SERIES *b*. TABLE IX.

EFFECT OF VARYING THE PRESSURE ON THE SAME EXTENT OF SURFACE.
$S=32$ square inches.

Number of experiment.		Nature of material.	P, amount of pressure.	p, pressure per square inch $=\frac{P}{S}$	R, wt. to overcome friction of motion.		C, coeff. of friction of motion $=\frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.
					For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.	
			tons	lbs.	lbs.	lbs.		°	ft. per sec	
145	1 2 3	Oak drawn through oak.	0·50	35	371 383 371	375	·334	30	3·79	15
146	1 2 3		0·75	52·5	655 655 670	660	·333	30	3·79	15
147	1 2 3		1·00	70	992 860 860	904	·403	30	3·79	18
148	1 2 3		1·25	87·5	1090 1030 1035	1052	·375	30	3·79	24
149	1 2 3		1·50	105	1130 1160 1080	1123	·334	30	3·79	18
150	1 2 3		1·75	122·5	1245 1245 1300	1263	·322	30	3·79	12
151	1 2 3		2·00	140	1415 1415 1465	1432	·320	30	3·79	12
152	1 2 3		2·25	157·5	1510 1553 1520	1528	·303	30	3·79	10
153	1 2 3		2·50	175	1710 1715 1710	1712	·305	30	3·79	15

TABLE X.

154	1 2 3	Wrought-iron drawn through wrought-iron.	0·50	35	473 500 435	469	·418	20	2·54	8
155	1 2 3		0·75	52·5	685 720 630	679	·403	20	2·54	7·5
156	1 2 3		1·00	70	900 1015 970	962	·425	30	3·79	
157	1 2 3		1·25	87·5	1500 1535 1450	1495	·533	30	3·79	
158	1 2 3		1·50	105	1945 1980 1850	1925	·573	30	3·79	
159	1 2 3		1·75	122·5	2235 2227 2215	2226	·568	30	3·79	
160	1 2 3		2·00	140	2425 2460 2460	2448	·546	45	5·61	
161	1 2 3		2·25	157·5	2735 2770 2715	2740	·543	45	5·61	
162	1 2 3		2·50	175	3015 3015 3025	3018	·538	45	5·61	

Table XI.

Number of experiment.		Nature of material.	P, amount of pressure.	p, pressure per square inch $=\frac{P}{S}$	R, wt. to overcome friction of motion.		C, coeff. of friction of motion $=\frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.
					For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.	
			tons	lbs.	lbs.	lbs.		°	ft. per sec	
163	1	Oak drawn through wrought-iron.	0·50	35	355	365	·331	20	2·54	4
	2				370					
	3				370					
164	1		0·75	52·5	560	577	·343	20	2·54	4
	2				600					
	3				570					
165	1		1·00	70	740	737	·329	30	3·79	6
	2				740					
	3				730					
166	1		1·25	87·5	920	940	·337	30	3·79	4
	2				950					
	3				950					
167	1		1·50	105	1140	1147	·341	30	3·79	5
	2				1150					
	3				1150					
168	1		1·75	122·5	1340	1360	·347	30	3·79	6
	2				1370					
	3				1370					
169	1		2·00	140	1580	1593	·355	30	3·79	6
	2				1600					
	3				1600					
170	1		2·25	157·5	1774	1773	·352	30	3·79	6
	2				1774					
	3				1770					
171	1		2·50	175	2100	2093	·373	30	3·79	6
	2				2080					
	3				2100					

Table XII.

172	1	Wrought-iron drawn through oak.	0·50	35	373	370	·330	30	3·79	9
	2				365					
	3				373					
173	1		0·75	52·5	500	494	·294	30	3·79	10
	2				496					
	3				485					
174	1		1·00	70	735	737	·324	30	3·79	10
	2				735					
	3				740					
175	1		1·25	87·5	955	943	·336	30	3·79	8
	2				940					
	3				935					
176	1		1·50	105	1152	1145	·340	30	3·79	12
	2				1147					
	3				1135					
177	1		1·75	122·5	1350	1335	·340	30	3·79	10
	2				1335					
	3				1320					
178	1		2·00	140	1535	1543	·344	30	3·79	9
	2				1560					
	3				1535					
179	1		2·25	157·5	1700	1697	·336	30	3·79	13
	2				1690					
	3				1700					
180	1		2·50	175	1975	1957	·349	30	3·79	12
	2				1965					
	3				1930					

Table XIII.

Number of experiment.		Nature of material.	P, amount of pressure.	p, pressure per square inch $= \frac{P}{S}$	R, wt. to overcome friction of motion.		C, coeffi. of friction of motion $= \frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.
					For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.	
			tons	lbs.	lbs.	lbs.		°	ft. per sec	
181	1	Teak drawn through teak.	0·50	35	419	409	·365	30	3·79	6·7
	2				409					
	3				399					
182	1		0·75	52·5	591	588	·350	30	3·79	6
	2				581					
	3				591					
183	1		1·00	70	731	724	·323	30	3·79	4
	2				721					
	3				721					
184	1		1·25	87·5	1003	1000	·357	30	3·79	5·3
	2				1008					
	3				989					
185	1		1·50	105	1161	1151	·343	40	...	5·1
	2				1146					
	3				1146					
186	1		1·75	122·5	1370	1377	·351	50	...	6
	2				1390					
	3				1370					
187	1		2·00	140	1649	1637	·365	60	...	5
	2				1649					
	3				1614					
188	1		2·25	157·5	1808	1795	·356	60	...	5·1
	2				1788					
	3				1788					
189	1		2·50	175	1788	1852	·331	60	...	4
	2				1919					
	3				1850					

Table XIV.

190	1	Teak drawn through wrought-iron.	0·50	35	400	392	·348	30	3·79	3·7
	2				388					
	3				388					
191	1		0·75	52·5	537	518	·308	30	3·79	1·5
	2				514					
	3				504					
192	1		1·00	70	637	644	·287	30	3·79	1
	2				652					
	3				642					
193	1		1·25	87·5	746	723	·258	30	3·79	1
	2				711					
	3				711					
194	1		1·50	105	850	863	·257	30	3·79	0·6
	2				870					
	3				870					
195	1		1·75	122·5	988	980	·250	30	3·79	0·6
	2				963					
	3				988					
196	1		2·00	140	1093	1093	·244	30	3·79	0·6
	2				1093					
	3				1093					
197	1		2·25	157·5	1232	1198	·238	33	...	0·6
	2				1198					
	3				1163					
198	1		2·50	175	1336	1336	·239	30	3·79	0·7
	2				1336					
	3				1336					

Table XV.

Number of experiment.		Nature of material.	*P*, amount of pressure.	*p*, pressure per square inch $=\frac{P}{S}$	*R*, wt. to overcome friction of motion.		*C*, coeff. of friction of motion $=\frac{R}{P}$	*I*, impact of *b*.		*M*, motion of the piece drawn through in inches per minute.
					For each expmt.	Mean.		*A*, mean angular fall of *b*.	*V*, velocity of *b*.	
			tons	lbs.	lbs.	lbs.		°	ft. per sec	
199	1 2 3	Wrought-iron drawn through teak.	0·50	35	287 297 287	290	·259	30	3·79	2·2
200	1 2 3		0·75	52·5	357 367 367	364	·217	30	3·79	2
201	1 2 3		1·00	70	496 486 496	493	·220	30	3·79	1·6
202	1 2 3		1·25	87·5	607 607 617	610	·218	30	3·79	1·1
203	1 2 3		1·50	105	746 731 731	736	·219	30	3·79	1·5
204	1 2 3		1·75	122·5	850 850 885	862	·220	30	3·79	1·5
205	1 2 3		2·00	140	1113 1092 1103	1103	·246	40	...	1·8
206	1 2 3		2·25	157·5	1254 1231 1242	1242	·246	45	5·61	1·6
207	1 2 3		2·50	175	1370 1336 1356	1354	·242	45	5·61	1·7

Table XVI.

208	1 2 3	Ground iron drawn through ground iron.	0·50	35	487 504 510	500	·446	30	3·79	
209	1 2 3 4 5 6 7 8 9 10		0·75	52·5	722 757 826 722 757 687 722 717 625 826	736	·438	30	3·79	Limits o variation 10″ and 4″. Mean 7″.

TABLE XVI.—*Continued.*

Number of experiment.		Nature of material.	P, amount of pressure.	p, pressure per square inch $= \frac{P}{S}$	R, wt. to overcome friction of motion.		C, coeffi. of friction of motion $= \frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.
					For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.	
			tons	lbs.	lbs.	lbs.		°	ft. per sec	
210	1	Ground iron drawn through ground iron.	1·00	70·0	987	954	·426	25		Limits of variation 10 and 1·5. Mean 5·1.
	2				885					
	3				1022					
	4				905					
	5				885					
	6				1042					
211	1		1·25	87·5	1056	1186	·423	30	3·79	Limits of variation, 8″ and 0″ Mean 2·6.
	2				1160					
	3				1225					
	4				1091					
	5				1146					
	6				1180					
	7				1250					
	8				1195					
	9				1215					
	10				1230					
	11				1299					
212	1		1·50	105	1542	1272	·379	30	3·79	Limits of variation, 20 and 1. Mean 5.
	2				1507					
	3				1368					
	4				1368					
	5				952					
	6				1041					
	7				1125					
213	1		1·75	122·5	1368	1251	·319	30	3·79	Limits of variation, 10 and 0. Mean 3·2.
	2				1403					
	3				1091					
	4				1125					
	5				1265					
	6				1299					
	7				1195					
	8				1265					
214	1		2·00	140	1403	1444	·322	30	3·79	Limits of variation, 20 and 0. Mean 2·6.
	2				1611					
	3				1265					
	4				1334					
	5				1403					
	6				1472					
	7				1368					
	8				1472					
	9				1502					
	10				1611					
215	1		2·25	157·5	1923	1621	·321	30	3·79	Limits of variation, 12 and 0. Mean 2·7.
	2				1507					
	3				1577					
	4				1715					
	5				1507					
	6				1577					
	7				1542					
216	1		2·50	175	1992	1674	·299	30	3·79	Limits of variation, 12 and 7. Mean 2.
	2				1785					
	3				1577					
	4				1507					
	5				1715					
	6				1785					
	7				1507					
	8				1527					

TABLE XVII.

GENERAL SUMMARY OF SERIES *b*.

Pressures from 0·5 to 2·5 tons. *S* = 32 square inches.

Pressure										
Per 32 sq. inches, tons	0·50	0·75	1·0	1·25	1·50	1·75	2·0	2·25	2·50	Mean.
Per 1 sq. inch, lbs.	35·0	52·5	70·0	87·5	105	122·5	140	157·5	175	
Oak through oak:—										
Mean value of R, lbs.	375	660	904	1052	1123	1263	1432	1528	1712	
Coefficient	·334	·333	·403	·375	·334	·322	·320	·303	·305	·337
Motion per minute, ins.	15	15	18	24	18	12	12	10	5	14
Oak through surfaced iron:—										
Mean value of *R*, lbs.	365	577	737	940	1147	1360	1593	1773	2093	
Coefficient	·331	·343	·329	·337	·341	·347	·355	·352	·373	·345
Motion per minute, ins.	4	4	6	4	5	6	6	6	6	5
Surfaced iron through oak:—										
Mean value of *R*, lbs.	370	494	737	943	1145	1335	1543	1697	1957	
Coefficient	·330	·294	·324	·336	·340	·340	·344	·336	·349	·333
Motion per minute, ins.	9	10	10	8	12	10	9	13	12	10
Surfaced iron through surfaced iron:—										
Mean value of *R*, lbs.	469	679	962	1495	1925	2226	2448	2740	3018	
Coefficient	·418	·403	·425	·533	·573	·568	·546	·543	·538	·505
Motion per minute, ins.	8	7·5								
Teak through teak:—										
Mean value of *R*, lbs.	409	588	724	1000	1151	1377	1637	1795	1852	
Coefficient	·365	·350	·323	·357	·343	·351	·365	·356	·331	·349
Motion per minute, ins.	6·7	6	4	5·3	5·1	6	5	5·1	4	5·2
Teak through surfaced iron:—										
Mean value of *R*, lbs.	392	518	644	723	863	980	1093	1198	1336	
Coefficient	·348	·308	·287	·258	·257	·250	·244	·238	·239	·270
Motion per minute, ins.	3·7	1·5	1	1	0·6	0·6	0·6	0·6	0·7	1·1
Surfaced iron through teak:—										
Mean value of *R*, lbs.	290	364	493	610	736	862	1103	1242	1354	
Coefficient	·259	·217	·220	·218	·219	·220	·246	·246	·242	·232
Motion per minute, ins.	2·2	2·0	1·6	1·1	1·5	1·5	1·8	1·6	1·7	1·7
Ground iron through ground iron:—										
Mean value of *R*, lbs.	500	736	954	1186	1272	1251	1444	1621	1674	
Coefficient	·446	·438	·426	·423	·379	·319	·322	·321	·299	·375
Motion per minute, ins.	...	7	5·1	2·6	5·0	3·2	2·6	2·7	2	3·8

SERIES *c*. TABLE XVIII.

EFFECT OF VARYING THE NUMBER OF SURFACES, WITH A CONSTANT PRESSURE (*P*) OF ·5 TON,

p = pressure per sq. in. of each surface = 35 lbs.
S = extent of each surface = 32 sq. inches.

Number of experiment.		Nature of material.	*N*, number of surfaces.	*R*, wt. to overcome friction of motion.		*C*, coeffi. of friction of motion $= \frac{R}{P}$	*I*, impact of *b*.		*M*, motion of the piece drawn through in inches per minute.
				For each expmt.	Mean.		*A*, mean angular fall of *b*.	*V*, velocity of *b*.	
				lbs.	lbs.		°	ft. per sec	
217	1	Wrought-iron through oak.	2	383	373	·333	30	3·79	8
	2			370					
	3			365					
218	1		4	715	717	·640	30	3·79	10
	2			720					
	3			715					
219	1		6	1170	1167	1·042	30	3·79	10
	2			1170					
	3			1165					
220	1		8	1592	1585	1·415	30	3·79	12
	2			1582					
	3			1582					
221	1		10	1978	1986	1·773	30	3·79	15
	2			1983					
	3			1998					

TABLE XIX.

222	1	Oak through wrought-iron.	2	515	508	·454	30	3·79	10
	2			505					
	3			505					
223	1		4	992	1015	·907	30	3·79	10
	2			1027					
	3			1027					
224	1		6	1512	1508	1·347	30	3·79	12
	2			1512					
	3			1500					
225	1		8	2068	2034	1·816	30	3·79	15
	2			2002					
	3			2033					
226	1		10	2554	2519	2·249	45	5·61	15
	2			2484					
	3			2519					

TABLE XX.

Number of experiment.		Nature of material.	N, number of surfaces.	R, wt. to overcome friction of motion.		C, coeff. of friction of motion $= \frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.
				For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.	
				lbs.	lbs.		°	ft. per sec	
227	1 2 3	Oak through oak.	2	496 471 496	488	·436	30	3·79	20
228	1 2 3		4	965 1000 1000	988	·882	30	3·79	20
229	1 2 3		6	1455 1520 1385	1453	1·300	30	3·79	30
230	1 2 3		8	1927 1927 1997	1950	1·741	45	5·61	30
231	1 2 3		10	2302 2347 2207	2285	2·040	45	5·61	30

TABLE XXI.

232	1 2 3	Wrought-iron through wrought-iron.	2	680 645 660	662	·590	10	1·277	
233	1 2 3		4	957 980 957	965	·861	10	1·277	
234	1 2 3		6	1368 1403 1378	1383	1·233			
235	1 2 3		8	1453 1533 1533	1506	1·345	7	·894	
236	1 2 3		10	1508 1543 1598	1550	1·384	7	·894	

TABLE XXII.

Number of experiment.		Nature of material.	N, number of surfaces.	R, wt. to overcome friction of motion.		C, coeffi. of friction of motion $= \frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.
				For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.	
				lbs.	lbs.		°	ft. per sec	
237	1	Teak drawn through teak.	2	714	707	·631	30	3·79	0·9
	2			704					
	3			704					
238	1		4	1373	1375	1·228	30	3·79	0·2
	2			1368					
	3			1383					
239	1		6	2088	2070	1·848	30	3·79	0·2
	2			2068					
	3			2053					
240	1		8	3021	3062	2·734	30	3·79	1·1
	2			3050					
	3			3114					
241	1		10						
	2								
	3								

TABLE XXIII.

Number of experiment.		Nature of material.	N, number of surfaces.	R, wt. to overcome friction of motion.		C, coeffi. of friction of motion $= \frac{R}{P}$	I, impact of b.		M, motion of the piece drawn through in inches per minute.
				For each expmt.	Mean.		A, mean angular fall of b.	V, velocity of b.	
242	1	Teak through wrought-iron.	2	495	480	·429	30	3·79	2·25
	2			475					
	3			470					
243	1		4	1537	1525	1·362	30	3·79	2·5
	2			1537					
	3			1502					
244	1		6	2343	2355	2·103	30	3·79	2·5
	2			2378					
	3			2343					
245	1		8	3040	3063	2·735	30	3·79	3·5
	2			3109					
	3			3040					
246	1		10						
	2								
	3								

TABLE XXIV.

Number of experiment.		Nature of material.	*N*, number of surfaces.	*R*, wt. to overcome friction of motion.		*C*, coeffi. of friction of motion $= \frac{R}{P}$	*I*, impact of *b*.		*M*, motion of the piece drawn through in inches per minute.
				For each expmt.	Mean.		*A*, mean angular fall of *b*.	*V*, velocity of *b*.	
				lbs.	lbs.		°	ft. per sec	
247	1 2 3	Wrought-iron through teak.	2	699 689 679	689	·615	30	3·79	1·5
248	1 2 3		4	1502 1532 1546	1527	1·363	30	3·79	1·5
249	1 2 3		6	2343 2251 2276	2290	2·045	30	3·79	1·5
250	1 2 3		8	2901 2901 3040	2947	2·631	30	3·79	6
251	1 2 3		10						

TABLE XXV.

252	1 2 3	Ground iron through ground iron.	2	987 987 1007	994	·887	30	3·79	40
253	1 2 3		4	2063 2028 2063	2051	1·834	30	3·79	30
254	1 2 3		6	3729 3729 3729	3729	3·33	30	3·79	30
255	1 2 3		8	5118 5118 5079	5105	4·558	30	3·79	25
256	1 2 3		10						

TABLE XXVI.

GENERAL SUMMARY OF SERIES *c*.

Pressure (P) = 0·5 ton. S = 32 square inches.

	Number of surfaces = N =	2	4	6	8	10	Mean.
Oak through oak.	Mean value of R, lbs.	488	988	1453	1950	2285	
	Coefficient for N surfaces = C ...	·436	·882	1·300	1·741	2·04	
	„ 1 „ $=\frac{C}{N}$...	·218	·221	·217	·218	·204	·215
	Motion per minute, ins.	20	20	30	30	30	26
Oak through surfaced iron.	Mean value of R, lbs.	508	1015	1508	2034	2519	
	Coefficient for N surfaces = C ...	·454	·907	1·347	1·816	2·249	
	„ 1 „ $=\frac{C}{N}$...	·227	·227	·225	·227	·225	·226
	Motion per minute, ins.	10	10	12	15	15	12
Surfaced iron through oak.	Mean value of R, lbs.	373	717	1167	1585	1986	
	Coefficient for N surfaces = C ...	·333	·640	1·042	1·415	1·773	
	„ 1 „ $=\frac{C}{N}$...	·167	·160	·174	·177	·177	·171
	Motion per minute, ins.	8	10	10	12	15	11
Surfaced iron through surfaced iron.	Mean value of R, lbs.	662	965	1383	1506	1550	
	Coefficient for N surfaces = C ...	·590	·861	1·233	1·345	1·384	
	„ 1 „ $=\frac{C}{N}$...	·295	·215	·206	·168	·138	·204
	Motion per minute, ins.						
Teak through teak.	Mean value of R, lbs.	707	1375	2070	3062		
	Coefficient for N surfaces = C ...	·631	1·228	1·848	2·734		
	„ 1 „ $=\frac{C}{N}$...	·316	·307	·308	·342	...	·318
	Motion per minute, ins.	0·9	0·2	0·2	1·1	...	0·6
Teak through surfaced iron.	Mean value of R, lbs.	480	1525	2355	3063		
	Coefficient for N surfaces = C ...	·429	1·362	2·103	2·735		
	„ 1 „ $=\frac{C}{N}$...	·215	·341	·351	·342	...	·312
	Motion per minute, ins.	2·25	2·5	2·5	3·5	...	2·7
Surfaced iron through teak.	Mean value of R, lbs.	689	1527	2290	2947		
	Coefficient for N surfaces = C ...	·615	1·363	2·045	2·631		
	„ 1 „ $=\frac{C}{N}$...	·308	·341	·341	·329	...	·330
	Motion per minute, ins.	1·5	1·5	1·5	6·0	...	2·6
Ground iron through ground iron.	Mean value of R, lbs.	994	2051	3729	5105		
	Coefficient for N surfaces = C ...	·887	1·834	3·33	4·558		
	„ 1 „ $=\frac{C}{N}$...	·444	·459	·555	·570	...	·507
	Motion per minute, ins.	40	30	30	25	...	31

SERIES *d*. TABLE XXVII.

EFFECT OF VARYING THE PRESSURE ON THE SAME EXTENT OF SURFACE.

S=32 square inches.
Statical friction, or friction of rest (i.e. without the use of impact).

Number of experiment.		Nature of material.	*P*, amount of pressure.	*p*, pressure per square inch $=\frac{P}{S}$	*R*, wt. to overcome friction of motion.		*C*, coeffi. of friction of motion $=\frac{R}{P}$	*M*, motion of the piece drawn through in inches per minute.	Dynamical friction, or friction of motion, see Table XVII. p. 147.	
					For each expmt.	Mean.			*C*.	*M*.
			tons	lbs.	lbs.	lbs.				
257	1	Oak drawn through oak.	0·50	35	557	566	·505	80″ to 100″ per minute.	·334	Mean rate 16″ per minute.
	2				617					
	3				524					
258	1		0·75	52·5	781	845	·503		·333	
	2				880					
	3				746					
	4				905					
	5				914					
259	1		1·00	70·0	1266	1258	·562		·403	
	2				1228					
	3				1217					
	4				1321					
260	1		1·25	87·5	1440	1436	·513		·375	
	2				1564					
	3				1436					
	4				1405					
	5				1336					
261	1		1·5	105	1614	1590	·473		·334	
	2				1405					
	3				1604					
	4				1544					
	5				1783					
262	1		1·75	122·5	1753	1788	·457		·322	
	2				1857					
	3				1753					
	4				1788					
263	1		2·00	140	2023	2038	·455		·320	
	2				1959					
	3				2093					
	4				2078					

TABLE XXVIII.

264	1	Oak drawn thro' wrought-iron.	0·50	35	534	594	·530	About 40″ per minute.	·331	Mean rate about 5″ per minute.
	2				538					
	3				652					
	4				637					
	5				607					
265	1		0·75	52·5	1023	975	·580		·343	
	2				988					
	3				954					
	4				988					
	5				920					
266	1		1·0	70	1231	1317	·588		·329	
	2				1336					
	3				1365					
	4				1336					

TABLE XXVIII.—*Continued.*

Number of experiment.		Nature of material.	P, amount of pressure.	p, pressure per square inch = $\frac{P}{S}$	R, wt. to overcome friction of motion.		C, coeff. of friction of motion = $\frac{R}{P}$	M, motion of the piece drawn through in inches per minute.	Dynamical friction, or friction of motion, see Table XVII. p. 147.	
					For each expmt.	Mean.			C.	M.
			tons	lbs.	lbs.	lbs.				
	1	Oak drawn through wrought-iron.			1474			About 40″ per minnte.		Mean rate about 5″ per minute.
267	2		1·25	87·5	1564	1514	·541		·337	
	3				1440					
	4				1579					
	1				1753					
268	2		1·50	105	1904	1874	·558		·341	
	3				1919					
	4				1919					
	1				2204					
269	2		1·75	122·5	2343	2313	·590		·347	
	3				2467					
	4				2239					
	1				2467					
270	2		2·00	140	2674	2579	·576		·355	
	3				2535					
	4				2641					

TABLE XXIX.

	1	Wrought-iron drawn through oak.			504			Mean rate about 27″ per minute.		Mean rate about 10″ per minute.
	2				514					
271	3		0·50	35	523	521	·465		·330	
	4				532					
	5				532					
	1				572					
	2		0·75	52·5	662	706	·420		·294	
272	3				781					
	4				810					
	5				706					
	1				1163					
	2				904					
273	3		1·00	70·0	870	996	·445		·324	
	4				1033					
	5				1008					
	1				1128					
	2				1336					
274	3		1·25	87·5	1288	1288	·460		·336	
	4				1321					
	5				1366					
	1				1475					
	2				1579					
275	3		1·50	105	1857	1727	·514		·340	
	4				1822					
	5				1904					
	1				2093					
	2				2579					
276	3		1·75	122·5	2355	2256	·575		·340	
	4				2161					
	5				2093					
	1				2301					
	2				2266					
277	3		2·00	140	2439	2387	·533		·344	
	4				2459					
	5				2469					

Table XXX.

Number of experiment.		Nature of material.	P, amount of pressure.	p, pressure per square inch $=\frac{P}{S}$	R. wt. to overcome friction of motion.		C, coeff. of friction of motion. $=\frac{R}{P}$	M, motion of the piece drawn through in inches per minute.	Dynamical friction, or friction of motion, see Table XVII. p. 147.	
					For each expmt.	Mean.			C.	M.
			tons	lbs.	lbs.	lbs.				
278	1	Wrought-iron drawn through wrought-iron.	0·50	35	443	437	·390	40	·418	Rate of motion very irregular, about 9″ per minute.
	2				410					
	3				443					
	4				453					
279	1		0·75	52·5	662	662	·394	60	·403	
	2				662					
	3				617					
	4				706					
280	1		1·00	70·0	1424	1255	·560	60	·425	
	2				1537					
	3				1581					
	4				885					
	5				850					
281	1		1·25	87·5	1356	1233	·440	50	·533	
	2				1356					
	3				1058					
	4				1197					
	5				1197					
282	1		1·50	105	1475	1569	·467	40	·573	
	2				1634					
	3				1440					
	4				1857					
	5				1440					
283	1		1·75	122·5	1857	1857	·473	20 to 60	·568	
	2				1914					
	3				1698					
	4				1960					
	5				1857					
284	1		2·00	140	1884	2029	·453	From barely sustained motion to 60″	·546	
	2				1954					
	3				2162					
	4				1857					
	5				2286					

Table XXXI.

285	1	Ground iron drawn through ground iron.	0·50	35	1425	1459	1·303]		·446	
	2				1492					
	3				1542					
	4				1502					
	5				1334					
286	1		1·00	70	2343	2548	1·137	40	·426	5·1
	2				2644					
	3				2619					
	4				2479					
	5				2654					
287	1		1·50	105	4003	3162	·941	40	·379	5
	2				4008					
	3				3071					
	4				3405					
	5				2689					
	6				2654					
	7				2308					
288	1		2·00	140	3140	3022	·675	40	·322	2·6
	2				2619					
	3				3106					
	4				3197					
	5				2619					
	6				3001					
	7				3475					
289	1		2·50	175	3648	3984	·711	40	·299	2
	2				3939					
	3				4077					
	4				3869					
	5				4389					

Table XXXII.

GENERAL SUMMARY OF SERIES *d*.

Pressures from 0·5 to 2·5 tons. *S* = 32 square inches.

Pressure		0·5	0·75	1·00	1·25	1·50	1·75	2·0	2·5	Mean.
	Per 32 sq. in., tons.	0·5	0·75	1·00	1·25	1·50	1·75	2·0	2·5	
	″ 1 ″ lbs.	35	52·5	70	87·5	105	122·5	140	175	
Oak through oak.	Mean value of *R*, lbs.	566	845	1258	1436	1590	1788	2038		
	Coefficient	·505	·503	·562	·513	·473	·457	·455	...	·495
Oak through surfaced iron.	Mean value of *R*, lbs.	594	975	1317	1514	1874	2313	2579		
	Coefficient	·530	·580	·588	·541	·558	·590	·576	...	·566
Surfaced iron through oak.	Mean value of *R*, lbs.	521	706	996	1288	1727	2256	2387		
	Coefficient	·465	·420	·445	·460	·514	·575	·533	...	·489
Surfaced iron through surfaced iron.	Mean value of *R*, lbs.	437	662	1255	1233	1569	1857	2029		
	Coefficient	·390	·394	·560	·440	·467	·473	·453	...	·454
Ground iron through ground iron.	Mean value of *R*, lbs.	1459	...	2548	...	3162	...	3022	3984	
	Coefficient	1·303	...	1·137	...	·941	...	·675	·711	·953

Table XXXIII.

SHEWING COMPARISON OF STATICAL AND DYNAMICAL COEFFICIENTS OF FRICTION.

Pressures from 0·5 to 2·5 tons. *S* = 32 square inches.

Pressure		0·5	0·75	1·0	1·25	1·50	1·75	2·00	2·5	Mean.
	Per 32 sq. ins., tons.	0·5	0·75	1·0	1·25	1·50	1·75	2·00	2·5	
	″ 1 ″ lbs.	35	52·5	70	87·5	105	122·5	140	175	
Oak through oak.	Statical	·505	·503	·562	·513	·473	·457	·455	...	·495
	Dynamical	·334	·333	·403	·375	·334	·322	·320	...	·346
Oak through surfaced iron.	Statical	·530	·580	·588	·541	·558	·590	·576	...	·566
	Dynamical	·331	·343	·329	·337	·341	·347	·355	...	·340
Surfaced iron through oak.	Statical	·465	·420	·445	·460	·514	·575	·533	...	·489
	Dynamical	·330	·294	·324	·336	·340	·340	·344	...	·330
Surfaced iron through surfaced iron.	Statical	·390	·394	·560	·440	·467	·473	·453	...	·454
	Dynamical	·418	·403	·425	·533	·573	·568	·546	...	·495
Ground iron through ground iron.	Statical	1·303	...	1·137	...	·941	...	·675	·711	·953
	Dynamical	·446	...	·426	...	·379	...	·322	·299	·376

Series *e*. Table XXXIV.

TO ASCERTAIN THE VALUE OF THE COEFFICIENTS OF DIFFERENT MATERIALS WITH VARIOUS PRESSURES AND WITH A CONSTANT SURFACE OF THIRTY-TWO SQUARE INCHES, UNDER THE SAME CONDITIONS OF "RATE OF MOTION" AND "WEAR."

TEAK THROUGH SURFACED IRON. *S* = 32 square inches.

Order of experiment.	Total pressure.	Value of *R*.	Coefficient of friction.	Rate per minute.	Remarks.	Order of experiment.	Total pressure.	Value of *R*.	Coefficient of friction.	Rate per minute.	Remarks.
	tons	lbs.		in.			tons	lbs.		in.	
1	0·5	329	·294	0·375	Blow used.	10	0·5	293	·260	0·50	Blow used.
		354	·316	0·75	″			344	·307	1·25	Blow not used.
		389	·347	1·25	Blow not used.			379	·338	2·00	″
		469	·418	3·00	″			335	·302	4·00	″
		489	·436	4·00	″			414	·370	5·00	″
		529	·488	7·50	″			449	·400	10·0	″
		554	·495	8·00	″			519	·463	12·0	″
		621	·554	12·00	″			546	·487	15·0	″
		678	·606	15·00	″			569	·508	20·0	″
		676	·603	20·0	″			693	·618	25·0	″
		747	·667	25·0	″			719	·642	30·0	″
		784	·700	30·0	″						
4	1·0	579	·258	0·375	Blow used.	7	1·0	594	·265	0·50	Blow used.
		748	·334	3·0	Blow not used.			610	·272	0·75	″
		857	·382	4·0	″			833	·369	4·0	Blow not used.
		872	·389	5·0	″			923	·412	7·0	″
		1083	·483	12·0	″			905	·404	10·0	″
		1130	·504	15·0	″			1151	·514	12·0	″
		1230	·549	20·0	″			1061	·474	15·0	″
		1270	·567	25·0	″			1214	·542	20·0	″
		1412	·652	30·0	″			1200	·536	25·0	″
								1527	·681	30·0	″
3	1·5	935	·278	0·375	Blow used.	8	1·5	919	·270	0·5	Blow used.
		1240	·369	2·00	Blow not used.			1149	·341	3·0	Blow not used.
		1240	·369	3·5	″			1166	·347	4·0	″
		1566	·466	5·0	″			1568	·466	8·0	″
		1513	·450	10·0	″			1583	·471	10·0	″
		1791	·533	12·0	″			1496	·445	12·0	″
		1791	·533	15·0	″			1840	·547	20·0	″
		2033	·605	20·0	″			1983	·590	25·0	″
		2068	·615	25·0	″			2132	·634	30·0	″
		2346	·698	30·0	″						
5	2	1267	·266	0·5	Blow used.	6	2	1206	·269	0·25	Blow used.
		1647	·367	2·0	″			1106	·247	0·50	″
		1861	·415	2·5	Blow not used.			1513	·337	0·875	Blow not used.
		1652	·364	3·0	″			1508	·336	1·5	″
		1639	·361	3·75	″			1808	·403	3·0	″
		1925	·427	5·0	″			1810	·405	5·0	″
		1776	·397	6·0	″			2068	·470	9·0	″
		2203	·489	10·0	″			2361	·529	12·0	″
		2184	·490	12·0	″			2311	·520	20·0	″
		2107	·470	15·0	″			2574	·576	25·0	″
		2342	·527	20·0	″			3041	·678	30·0	″
		2270	·508	25·0	″						
		2555	·576	30·0	″						
2	2·5	1582	·282	0·25	Blow used.	9	2·5	1491	·266	0·375	Blow used.
		2068	·369	1·25	″			1652	·295	1·25	Blow not used.
		2028	·371	2·0	Blow not used.			1652	·295	1·5	″
		2346	·419	2·5	″			1982	·354	4·0	″
		2385	·426	4·0	″			2107	·376	5·0	″
		2624	·468	4·5	″			2107	·376	8·0	″
		2385	·426	5·0	″			2538	·453	12·0	″
		2832	·506	12·0	″			3041	·543	15·0	″
		3041	·543	15·0	″			3094	·552	20·0	″
		3179	·567	20·0	″			3318	·592	25·0	″
		3318	·592	25·0	″			3613	·645	30·0	″
		3596	·642	30·0	″						

Table XXXV.

GROUND METAL THROUGH GROUND IRON. $S = 32$ square inches.

Order of experiment.	Total pressure.	Value of *R*.	Coefficient of friction.	Rate per minute.	Remarks.	Order of experiment.	Total pressure.	Value of *R*.	Coefficient of friction.	Rate per minute.	Remarks.
	tons	lbs.		in.			tons	lbs.		in.	
1	0·5	319	·285	0·25	Blow not used.	10	0·5	359	·320	0·125	Blow not used.
		319	·285	0·5	"			369	·329	0·25	"
		329	·294	1·25	"			389	·347	0·375	"
		354	·316	3·0	"			434	·387	1·5	"
		379	·338	8·0	"			434	·387	2·0	"
		354	·316	9·0	"			424	·378	3·0	"
		394	·352	12·0	"			481	·420	9·0	"
		404	·360	20·0	"			444	·396	12·0	"
		444	·396	30·0	"			514	·458	20·0	"
								534	·476	30·0	"
4	1	891	·398	0·125	"	7	1	899	·401	0·125	"
		840	·375	0·25	"			991	·442	2·5	"
		991	·442	3·75	"			1009	·450	3·5	"
		1020	·455	5·0	"			1046	·467	4·5	"
		956	·425	8·0	"			1185	·529	12·0	"
		1118	·499	15·0	"			1142	·509	15·0	"
		1095	·489	20·0	"			1222	·545	25·0	"
		1222	·545	25·0	"			1305	·582	30·0	"
		1251	·558	30·0	"						
3	1·5	1230	·366	0·125	"	8	1·5	1414	.421	0·125	"
		1081	·325	0·25	"			1592	·473	1·0	"
		1161	·345	1·0	"			1657	·490	3·0	"
		1449	·431	4·0	"			1742	·518	4·0	"
		1648	·490	12·0	"			1707	·508	5·0	"
		1419	·422	15·0	"			1824	·543	12·0	"
		1697	·505	25·0	"			1930	·574	20·0	"
		1810	·536	30·0	"			1861	·554	25·0	"
								2048	·609	30·0	"
5	2	1582	·353	0·125	"	6	2	1530	·342	0·125	"
		1582	·353	0·25	"			1513	·338	0·25	"
		1860	·415	2·5	"			1757	·392	0·5	"
		1895	·423	4·0	"			1881	·419	1·5	"
		2136	·477	12·0	"			1751	·391	4·0	"
		2439	·544	30·0	"			2159	·481	8·0	"
								1791	·400	9·0	"
								2062	·460	15·0	"
								2068	·461	20·0	"
								2068	·461	25·0	"
								2331	·520	30·0	"
2	2·5	1846	·329	0·125	"	9	2·5	1975	·352	0·062	"
		1888	·337	0·25	"			1999	·357	0·125	"
		1792	·320	0·375	"			2451	·437	1·5	"
		2059	·367	1·25	"			2142	·382	2·0	"
		2141	·382	2·0	"			2437	·435	2·5	"
		2402	·429	3·0	"			2107	·379	4·0	"
		2296	·410	4·0	"			2716	·485	6·0	"
		2277	·406	10·0	"			2385	·426	10·0	"
		2581	·457	12·0	"			2420	·432	12·0	"
		2346	·419	20·0	"			3007	·537	20·0	"
		2574	·456	25·0	"			2763	·493	25·0	"
		2781	·496	30·0	"			3004	·536	30·0	"

TABLE XXXVI.

TEAK THROUGH SURFACED IRON. *S* = 32 square inches.

Order of experiment.	Total pressure.	Value of *R*.	Coefficient of friction.	Rate per minute.	Remarks.	Order of experiment.	Total pressure.	Value of *R*.	Coefficient of friction.	Rate per minute.	Remarks.
	tons	lbs.		in.			tons	lbs.		in.	
1	0·5	361	·322	0·25	Blow not used.	10	0·5	407	·363	0·125	Blow not used.
		364	·325	0·75	〃			484	·432	2·0	〃
		372	·332	1·0	〃			469	·419	3·0	〃
		434	·387	15·0	〃			558	·498	12·0	〃
		469	·419	20·0	〃			538	·480	18·0	〃
		504	·450	25·0	〃			548	·489	20·0	〃
		484	·432	30·0	〃			613	·547	30·0	〃
4	1	712	·318	0·125	〃	7	1	799	·356	0·125	〃
		709	·317	0·187	〃			943	·421	1·25	〃
		907	·405	1·75	〃			933	·416	2·0	〃
		1016	·454	5·0	〃			933	·416	3·0	〃
		985	·439	9·0	〃			1090	·487	3·5	〃
		1085	·484	12·0	〃			1071	·478	4·0	〃
		1263	·563	20·0	〃			1071	·478	10·0	〃
		1263	·563	25·0	〃			1071	·478	15·0	〃
								1212	·541	20·0	〃
								1232	·550	25·0	〃
								1212	·541	30·0	〃
3	1·5	1151	·342	0·375	〃	8	1·5	1197	·356	0·062	〃
		1290	·383	1·5	〃			1172	·349	0·25	〃
		1200	·357	2·0	〃			1236	·368	1·25	〃
		1235	·367	4·0	〃			1475	·439	4·0	〃
		1442	·429	5·0	〃			1445	·430	5·0	〃
		1402	·417	7·5	〃			1484	·442	8·0	〃
		1583	·472	8·5	〃			1651	·491	12·0	〃
		1531	·456	12·0	〃			1733	·516	15·0	〃
		1565	·465	15·0	〃			1757	·523	20·0	〃
		1714	·510	20·0	〃			1980	·589	30·0	〃
		1835	·578	30·0	〃						
5	2	1375	·307	0·25	〃	6	2	1522	·339	0·125	〃
		1361	·305	0·75	〃			1628	·363	0·25	〃
		1687	·376	1·0	〃			1860	·415	0·75	〃
		1714	·385	2·5	〃			1905	·447	2·0	〃
		1747	·390	3·0	〃			2131	·475	5·0	〃
		1639	·388	4·0	〃			2243	·501	7·0	〃
		1990	·444	12·0	〃			2018	·450	12·0	〃
		1965	·438	15·0	〃			2521	·563	20·0	〃
		2172	·485	20·0	〃			2401	·536	25·0	〃
		2292	·512	30·0	〃			2356	·525	30·0	〃
2	2·5	2017	·360	0·125	〃	9	2·5	2000	·357	0·125	〃
		2105	·376	0·25	〃			2068	·369	0·375	〃
		2068	·369	0·375	〃			2278	·407	0·75	〃
		2262	·406	1·25	〃			2451	·437	1·25	〃
		2540	·453	2·5	〃			2624	·468	3·0	〃
		2556	·456	4·0	〃			2833	·506	5·0	〃
		2540	·453	6·0	〃			2902	·508	12·0	〃
		2540	·453	12·0	〃			3111	·555	25·0	〃
		2966	·530	20·0	〃			3179	·567	30·0	〃
		3027	·540	30·0	〃						

Table XXVII.

GROUND IRON THROUGH GROUND IRON. S = 32 square inches.

Order of experiment.	Total pressure.	Value of R.	Coefficient of friction.	Rate per minute.	Remarks.	Order of experiment.	Total pressure.	Value of R.	Coefficient of friction.	Rate per minute.	Remarks.
	tons	lbs.		in.			tons	lbs.		in.	
1	0·5	355	·317	3·0	Blow not used.	10	0·5	484	·432	10·0	Blow not used.
		360	·321	5·0	Blow used.			504	·450	10·0	Blow used.
		375	·334	8·0	Blow not used.			523	·467	10·0	〃
		365	·326	10·0	Blow used.			528	·471	10·0	〃
		410	·366	15·0	〃			573	·511	10·0	Blow not used.
		459	·410	20·0	Blow not used.			588	·525	10·0	〃
4	1	1146	·511	20·0	Blow used.	7	1	1102	·492	20·0	〃
		1146	·511	20·0	〃			1181	·531	20·0	Blow used.
		1136	·507	20·0	〃			1254	·559	20·0	Blow not used.
		1216	·542	20·0	Blow not used.			1341	·599	20·0	〃
		1251	·559	20·0	〃			1343	·600	20·0	Blow used.
		1282	·572	20.0	〃			1404	·622	20·0	〃
3	1·5	1507	·450	12·0	Blow used.	8	1·5	2378	·707	15·0	〃
		1383	·412	15·0	Blow not used.			2176	·647	15·0	Blow not used.
		1414	·421	15·0	Blow used.			2082	·619	20·0	Blow used.
		1293	·385	15·0	〃			2475	·736	20 0	〃
		1489	·443	15·0	Blow not used.			1857	·552	20·0	Blow not used.
		1404	·418	20·0	〃			2092	·662	20·0	〃
5	2	1925	·429	20·0	〃	6	2	2010	·449	20·0	Blow used.
		1958	·437	20·0	〃			2063	·462	20·0	〃
		2227	·497	20·0	〃			2479	·553	20·0	〃
		1935	·431	30·0	Blow used.			2218	·495	20·0	Blow not used.
		2167	·483	30·0	〃			2620	·584	20·0	〃
		2483	·554	30·0	〃			2635	·588	20·0	〃
2	2·5	1944	·347	2·0	〃	9	2·5	3033	·541	4·0	〃
		2098	·374	3·0	〃			3208	·588	5·0	〃
		2011	·459	4·0	Blow not used.			3351	·598	15·0	Much scored.
		2028	·462	5·0	〃			2618	·467	20·0	Blow used.
		2144	·483	5·0	〃			2856	·510	20·0	〃
		2159	·385	10·0	Blow used.			2885	·515	20·0	〃

Table XXXVIII.

GENERAL SUMMARY OF SERIES *e*.

$S = 32$ square inches. Mean pressure = 1·5 tons.

Pressures.		0·5 tons.			1 ton.			1·5 tons.			2 tons.			2·5 tons.			Mean at each rate.
Number of experiment.		1	10	Mean.	4	7	Mean.	3	8	Mean.	5	6	Mean.	2	9	Mean.	
Rate per min. about																	
Teak through surfaced iron.	0·5	·305	·260	·282	·258	·265	·261	·278	·270	·274	·266	·247	·256	·282	·266	·274	·270
	1·25	·347	·307	·327	...	...	...	...	...	...	·367	·336	·352	·369	·295	·332	·337
	3·0	·418	·320	·369	·334	·369	·351	·369	·341	·355	·364	·403	·383	·419	·354	·386	·369
	7·5	·488	·385	·436	...	·412	·412	·458	·466	·452	·397	·438	·418	·426	·376	·401	·427
	12·0	·554	·463	·508	·483	·514	·498	·533	·445	·489	·490	·529	·509	·506	·453	·479	·497
	15·0	·606	·487	·546	·504	·474	·489	·533	...	·533	·470	...	·470	·543	·543	·543	·520
	20·0	·603	·508	·555	·549	·542	·545	·605	·547	·576	·527	·520	·523	·567	·552	·559	·552
	25·0	·667	·618	·642	·567	·536	·551	·615	·590	·602	·508	·576	·542	·592	·592	·592	·586
	30·0	·700	·642	·671	·652	·681	·666	·698	·634	·666	·576	·678	·627	·642	·645	·643	·655
Ground metal through ground iron.	0·25	·285	·329	·307	·375	·401	·386	·325	·421	·373	·353	·338	·345	·337	·357	·347	·352
	0·5	·285	·347	·316	...	...	...	...	...	...	...	·392	·392	·320	...	·320	·336
	1·25	·294	·387	·340	...	...	...	·345	·473	·409	...	...	...	·367	·437	·402	·384
	3·0	·316	·378	·347	·442	·446	·444	...	·490	·490	·415	·391	·403	·429	·435	·432	·416
	5·0	...	...	...	·455	·467	·461	·431	·508	·470	·423	...	·423	·410	·432	·421	·447
	7·5	·338	·420	·379	·425	...	·425	...	...	...	...	·481	·481	·406	·426	·416	·416
	12·0	·352	·396	·374	...	·529	·529	·490	·543	·516	·477	...	·477	·457	·432	·450	·459
	15·0	...	...	...	·499	·509	·504	·422	...	·422	...	·460	·460	...	...	...	·473
	20·0	·360	·458	·409	·489	...	·489	...	·574	·574	...	·461	·461	·419	·537	·478	·471
	25·0	...	...	...	·545	·545	·545	·505	·554	·530	...	·461	·461	·456	·493	·475	·508
	30·0	·396	·476	·436	·558	·582	·570	·536	·609	·572	·544	·520	·532	·496	·536	·516	·525
Metal through surfaced iron.	0·25	·322	·363	·342	·318	·356	·337	·342	·349	·345	·307	·363	·335	·376	·336	·370	·346
	1·25	·332	·432	·382	·405	·421	·413	·383	·368	·375	·376	·415	·396	·406	·437	·422	·398
	3·0	...	·419	·419	...	·416	·416	·362	·439	·400	·390	·461	·426	·454	·468	·461	·429
	7·5	...	...	...	·446	·478	·462	·417	·442	·430	...	·501	·501	·453	·507	·480	·463
	12·0	...	·498	·498	·484	...	·484	·456	·491	·473	·444	·450	·447	·453	·508	·481	·473
	15·0	·387	·480	·433	...	·478	·478	·465	·516	·491	·438	...	·438	...	...	...	·461
	20·0	·419	·489	·454	·563	·541	·552	·510	·523	·517	·485	·563	·524	·530	...	·530	·514
	25·0	·450	...	·450	·563	·550	·556	...	...	...	...	·536	·536	·535	·555	·545	·531
	30·0	·432	·547	·489	...	·541	·541	·578	·589	·584	·512	·525	·519	·540	·567	·554	·537
Ground iron through ground iron.	3·0	·317	...	·317	...	...	...	...	...	...	...	...	...	·347	·541	·444	·402
	5·0	·321	...	·321	...	...	...	...	...	...	...	...	...	·472	·588	·530	·460
	10·0	·326	·476	·401	...	...	...	...	...	...	...	...	...	·385	...	·385	·396
	15·0	·366	...	·366	...	...	...	·416	·677	·547	...	...	...	...	·598	·598	·513
	20·0	·410	...	·410	·534	·567	·551	·418	·612	·513	·454	·522	·488	...	·497	·497	·502

Table XXXIX.

MEANS DEDUCED FROM TABLE XXXVIII.

Rate of motion per minute, ins.	″ 0·25	″ 0·5	″ 1·25	″ 3·0	″ 5·0	″ 7·5	″ 12	″ 15	″ 20	″ 25	″ 30
Teak through surfaced iron	...	·270	·337	·369	...	·427	·497	·520	·552	·586	·655
Ground metal through ground iron ...	·352	·336	·384	·416	·447	·416	·459	·473	·471	·508	·525
Metal through surfaced iron	·346	...	·398	·429	...	·463	·473	·461	·514	·531	·537
Ground iron through ground iron	...	...	...	·402	·460	...	...	·513	·502		
Mean	·349	·303	·373	·404	·454	·435	·476	·492	·510	·542	·572

TABLE XL.

TABLE OF CORRECTIONS TO OBTAIN COEFFICIENTS AT A COMMON RATE OF EIGHT INCHES PER MINUTE, DEDUCED FROM THE FAIR CURVE.

Fig. 2, Plate II.

Rate per minute	0·1″	0·2″	0·3″	0·4″	0·5″	0·6″	0·7″	0·8″	0·9″	1·0″	1·2″
Correction ……	+·135	+·131	+·127	+·123	+·119	+·116	+·113	+·109	+·106	+·104	+·097
Rate per minute	1·4″	1·6″	1·8″	2·0″	2·1″	2·4″	2·8″	3·0″	3·3″	3·5″	4·0″
Correction ……	+·091	+·085	+·079	+·074	+·071	+·064	+·056	+·052	+·048	+·044	+·037
Rate per minute	4·3″	4·5″	5·0″	6·0″	7·0″	8″	9″	10″	11″	12″	13″
Correction ……	+·033	+·030	+·024	+·015	+·007	0	−·006	−·011	−·017	−·023	−·029
Rate per minute	14″	15″	16″	17″	18″	19″	20″	22″	24″	25″	26″
Correction ……	−·034	−·039	−·043	−·047	−·051	−·055	−·059	−·068	−·076	−·081	−·086
Rate per minute	28″	30″	32″	34″	36″	38″	40″	45″	50″	55″	60″
Correction ……	−·095	−·103	−·111	−·117	−·123	−·129	−·135	−·152	−·160	−·171	−·181
Rate per minute	70″	73″	80″	90″	100″	120″	140″	160″	180″		
Correction ……	−·196	−·200	−·209	−·217	−·223	−·233	−·240	−·244	−·245		

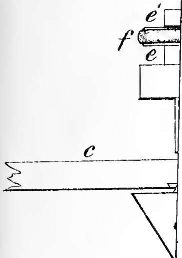
The corrections for rates over 30″ were obtained by prolonging the curve.

TABLE XLI.

SHEWING THE COEFFICIENTS OF SERIES *a*, TABLE VII AT A COMMON RATE OF EIGHT INCHES PER MINUTE, OBTAINED BY MEANS OF TABLE XL.

Material through which drawn.	Oak.				Elm.				Teak.			
	64″	32″	16″	Mean.	64″	32″	16″	Mean.	64″	32″	16″	Mean.
Oak ……………………	·329	·216	·075	·207	·401	·275	·082	·253	·478	·296	·203	·325
Elm ……………………	·341	·248	·181	·257	·399	·302	·112	·271	·538	·338	·231	·369
Teak ……………………	·397	·348	·270	·338	·413	·355	·281	·350	·483	·374	·316	·391
Pine ……………………	·516	·416	·382	·438	·494	·407	·391	·431	·488	·428	·389	·435
Wrought-iron ………	·437	·332	·307	·359	·390	·412	·294	·365	·379	·333	·291	·334
Gun-metal …………	·397	·376	·365	·379	·392	·339	·297	·343	·341	·316	·363	·340
	Pine.				Wrought-iron.				Gun-metal.			
Oak ……………………	·490	·372	·358	·407	·285	·322	·340	·316	·377	·335	·499	·404
Elm ……………………	·527	·390	·402	·440	·376	·366	·307	·350	·431	·368	·465	·421
Teak ……………………	·528	·408	·372	·436	·360	·411	·302	·358	·399	·379	·359	·379
Pine ……………………	·529	·446	·353	·443	·358	·342	·304	·335	·487	·420	·411	·439
Wrought-iron ………	·385	·351	·380	·372	·547	·358	·458	·454	·542	·504	·490	·512
Gun-metal …………	·483	·385	·368	·412	·524	·519	·526	·523	·658	·756	·741	·718

PLATE I.



Fig

Section of part o

shewing the acti

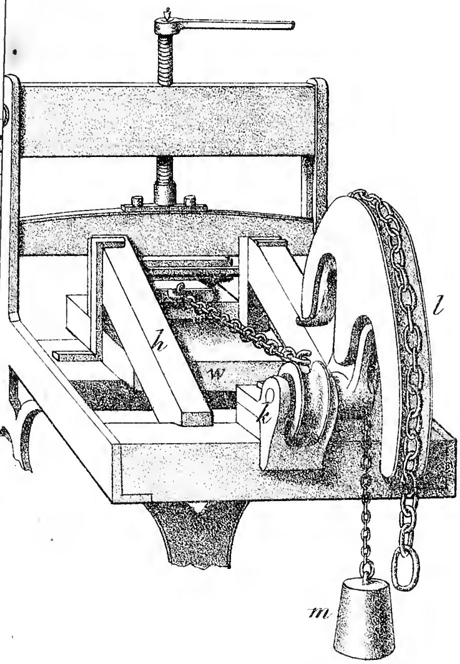
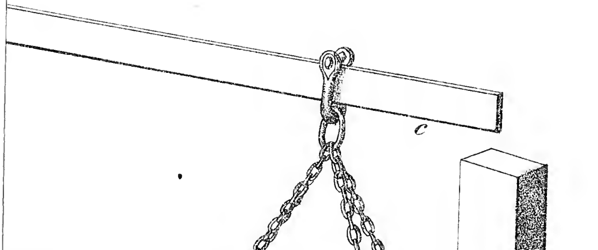


Fig 2.
General view, looking from the front.



Lithographed at the Royal Artillery Institution.

PLATE I

APPARATUS USED FOR THE EXPERIMENTS ON FRICTION.

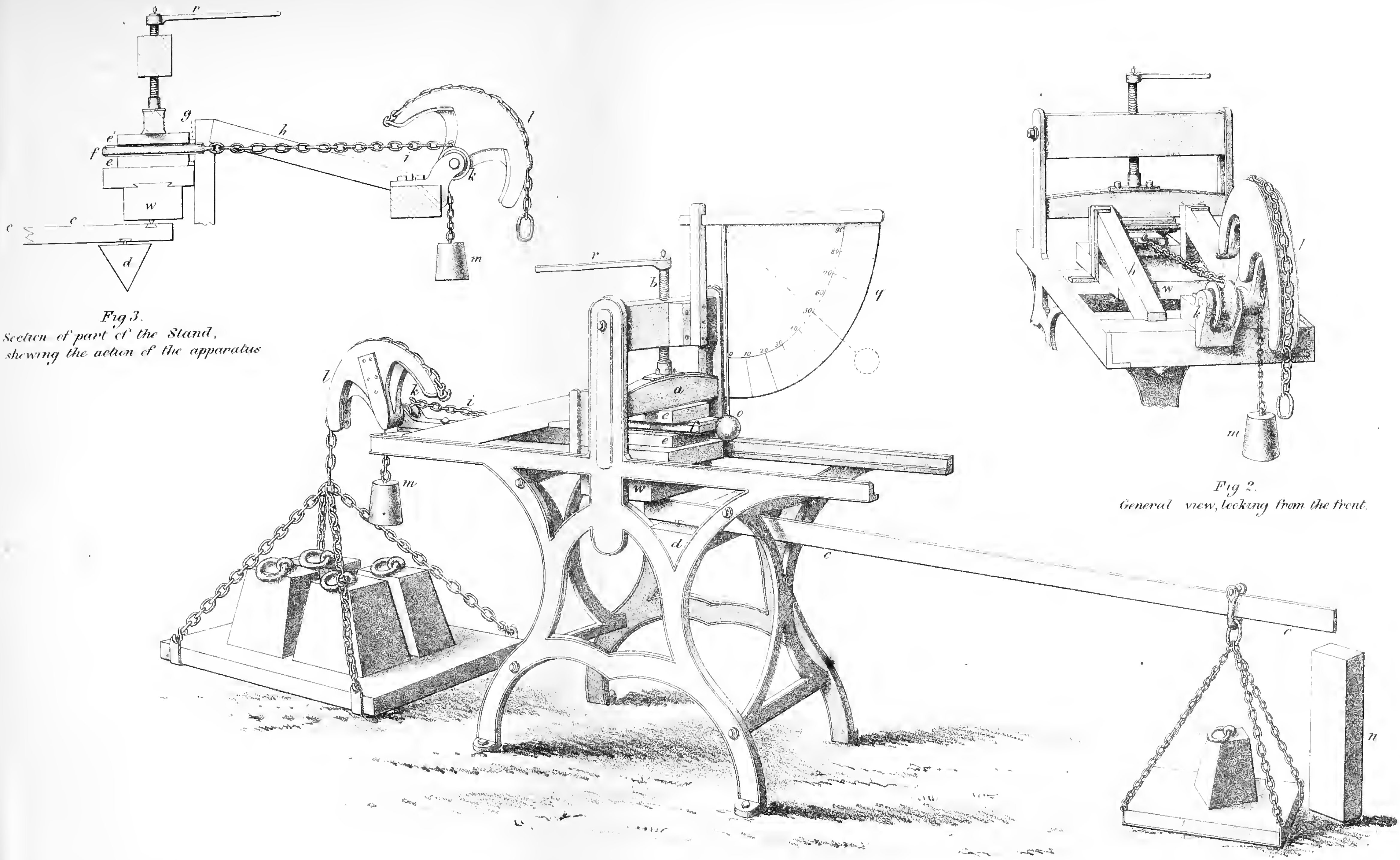


Fig 3.
Section of part of the Stand, shewing the action of the apparatus

Fig 2.
General view, looking from the front.

Fig 1.
General view, looking from the rear

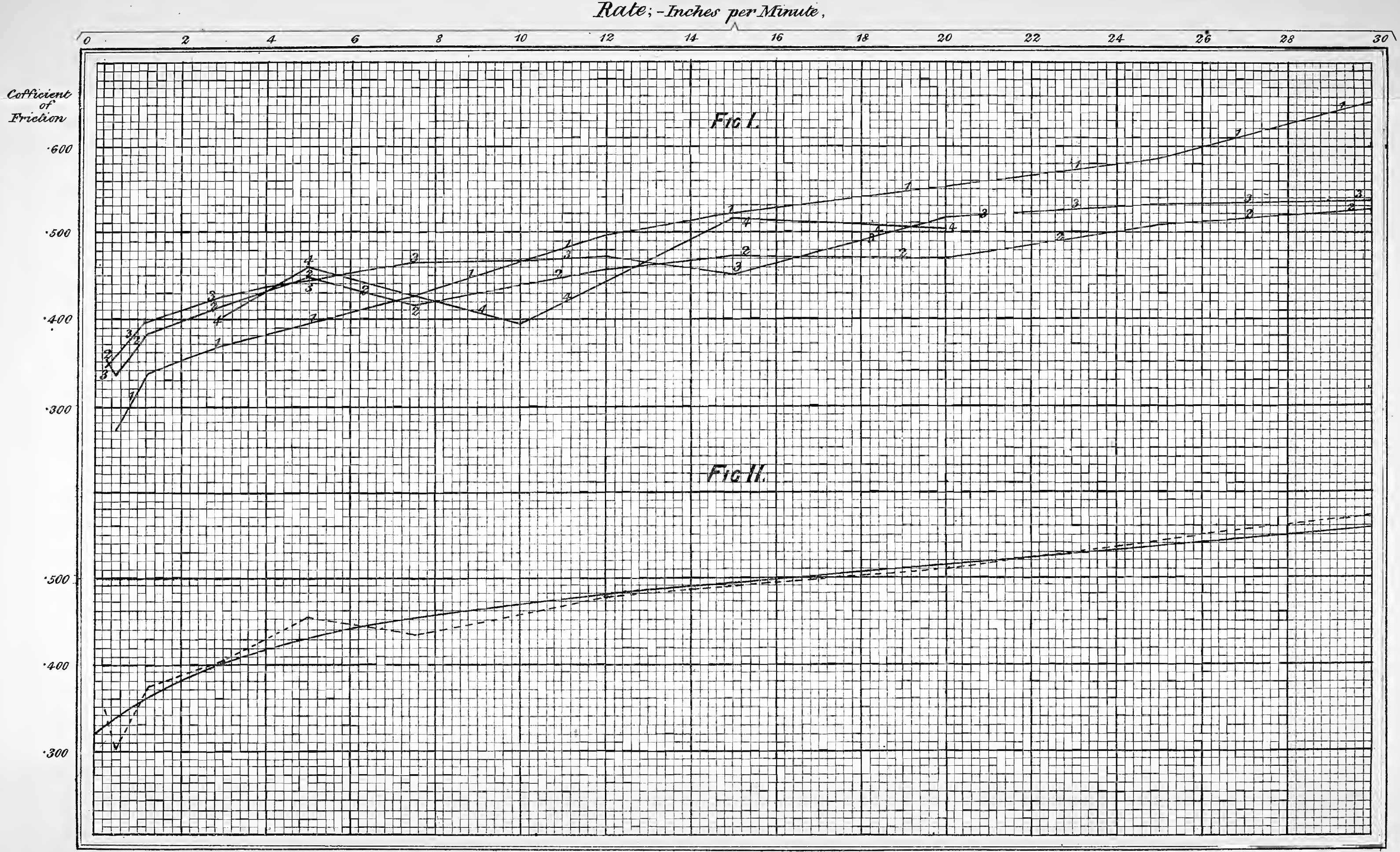
Lithographed at the Royal Artillery Institution

PLATE II.

CURVES SHEWING THE EFFECT OF VARYING THE RATE OF MOTION

(SERIES, *e*;-TABLES XXXVIII-XXXIX)

Mean Pressure =1·5 tons.



1. *Teak through Surfaced Iron*
2. *Ground Metal thro' Ground Iron*
3. *Metal through Surfaced Iron*
4. *Ground Iron thro' Ground Iron*

Lithographed at the Royal Artillery Institution

DIAGRAM Shewing the Coefficients of Series "A" at a common rate of motion of 8 Ins. per minute - from Table XLI. The coefficients due to the mean of the 3 surfaces are shewn by the shaded parts.

Lithographed at the Royal Artillery Institution.

ON THE CURVED RACK

IN

MONCRIEFF'S PROTECTED BARBETTE GUN CARRIAGE.

[COMMUNICATED BY JAMES WHITE, M.A.]

THE curve is traced by a fixed point in a wall upon a circular disc rolling against it along a right line. As applied in the carriage the rack of its form fastened to the elevators as they roll back turns a pinion on the rail by which the friction and pawle wheels are moved. But it is manifest that the curve is not limited by the circumference of the wheel or circular disc generating it; if the plane of the rolling circle (on which the curve is traced) be indefinitely extended, the curve might be prolonged without limit. It is in this general form that it is proposed here to consider it.

It should be remarked, to prevent misconception, that part of the curved rack in Captain Moncrieff's carriage is generated by that portion of the elevators which is not circular, but as that is very small, and also the form of this generating portion undetermined, it will not be taken into account.

The curve can be obtained by reversing the supposition, *i.e.* by considering the circle fixed while the line carrying the given point on its plane rolls round it. This will give one-half of the curve commencing from the point of it nearest the centre of the circle, the other half being equal and opposite. Thus it may be defined as the locus of a fixed point on the perpendicular to the normal of the involute of the circle; or, in other words, the locus of the extremity of a tangent of given length (p) to the involute.*

Taking the particular case in which the length of the tangent is equal to the radius of the circle ($p = a$) the curve is the spiral of Archimedes, whose equation is $\rho = a\omega$, for that is the *pedal* of the involute, or locus of foot of the perpendicular from the centre of the circle on the tangent to its involute, and the part intercepted on the tangent between that perpendicular and the normal is evidently equal to the radius. From this the general equation for any length (p) of the tangent can be easily deduced.

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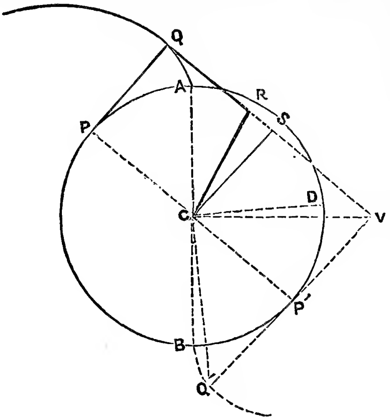
* The subject of involutes has been very extensively pursued, partly in connection with the curve here treated of, by Professor Sylvester. Vide Philosophical Magazine, Vol. XXXVI. p. 295, October, 1868.

Let PQ be the normal, and QS the tangent to the involute of the circle PAD. Then, let $QS = CP = a$, and S is a point on the spiral $\rho = a\omega$, and CS is the radius vector. Fig. 1.

Fig. 1.



Let $QR = p$ and $RS\,(= a - p) = d$, and it is required to find the equation of locus of R. CS will be its radius vector.

$$CR^2 = CS^2 + RS^2 = a^2\omega^2 + d^2,$$

consequently,

$$\rho^2 = a^2\omega^2 + d^2 ; \ \therefore \ \frac{\sqrt{\rho^2 - d^2}}{a} = \omega,$$

but ω is the angle made by CS with CD (at right angles with CA), therefore in terms of the angle θ made CR (ρ) with CD,

$$\omega = \theta - \angle RCS = \theta - \sin^{-1}\frac{d}{\rho};$$

$$\text{therefore } \frac{\sqrt{\rho^2 - d^2}}{a} = \theta - \sin^{-1}\frac{d}{\rho},$$

$$\text{or } \theta = \sin^{-1}\frac{d}{\rho} + \frac{\sqrt{\rho^2 - d^2}}{a}.$$

Professor Sylvester has proposed to call the rack of this form the "Moncrieffian," as it has been first used by Captain Moncrieff. The curves in general he has proposed to call "convolutes;" their existence has been occasionally slightly noticed, but their properties and application seem to have been entirely overlooked till Captain Moncrieff employed a rack of this form in his gun carriage.

Three cases of the curve are worthy of notice:—

(1) Let $p = 0$, that is let $d = a$, and then the curve becomes the involute of the circle. This may be found by making the substitution in the equation given above, remembering that for the Moncrieffian curve θ is measured from CD, but in the equation of the involute as usually given,

$$\theta = \frac{\sqrt{\rho^2 - a^2}}{a} - \cos^{-1}\frac{a}{\rho}$$

θ is measured from AC.

(2) Let $p = a$, or $d = 0$, then as before seen the curve is the spiral of Archimedes.

(3) Let $p = 2a$, or $d = -a$, and then the curve takes a remarkable form, which may be called the *counter-involute*. Taking its rise from B (the point diametrically opposed to A, see Fig. 1), its equation will differ from that of the involute commencing at the same point only in the sign of $\cos^{-1}\frac{a}{\rho}$, but its form will not be at all similar. The involute may be defined as the locus of a point taken on the tangents to a circle making the length of the tangent equal to the length of the arc from the point of contact to a fixed one on the circle. The counter-involute admits of the same definition; but the tangent is taken in the direction *from* and not *towards* the fixed point on the circle. It may be described as traced by the extremity of the line round the circle when rolled off backwards tangentially, instead of unwound directly, as in the case of the involute. This will be easily seen from the figure. Let $VS = QS$, and V is a point on the curve; draw VP' a tangent, and PCP' will be a diameter of the circle; produce QC to meet VP' in Q', and CQ' will equal CQ, and the angle BCQ' will equal ACQ; therefore Q' is a point on the involute commencing at B; and it is manifest that VP' is equal to QP, which is equal to $Q'P'$.

The involute and counter-involute may be described as tan $= s$; s being the arc of the circle from a fixed point to the point of contact of tangent. The Moncrieffian curve generally may be described as tan $= ks$; when $k = \frac{a}{d}$, and s is the arc of a circle whose radius is d. This is evident from Fig. 2,

$$BR = PQ = PA = k.BA':$$

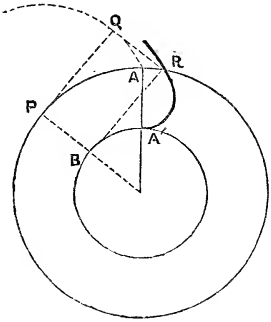


Fig. 2.

It may therefore be defined as the locus of the extremities of tangents to a given circle whose length is a given multiple of the length of the arc from their points of contact to a fixed point on the circle. The radius of that circle will be d of the equation given before. When p is greater than a, *i.e.* when d is negative the tangents must be measured from and not towards the fixed point on the circle, and the curve will resemble the counter-involute. By a common property of rolling curves it follows that the normal of the curve is PR in Fig. 1, the line joining the point of contact of the normal of the involute with the generating point. It will also be observed that the complete involute of a circle (*i.e.* when unrolled on both sides from the same point on the circumference) has a cusp, the counter-involute has none.

A brief notice of the mechanical application of the convolute or Moncrieffian curved rack may be added.

By a rack of this form a moving fulcrum can be controlled or applied; as however the fulcrum rolls the rack will pass through a fixed point, and therefore will act upon a wheel or pinion. Of the moving fulcrum, for which Captain Moncrieff first employed this curved rack, most valuable and important use has been made in his protected barbette gun carriage. The sudden and violent strain of the recoil of a heavy gun has not only been subdued but also utilized; and the principle may admit of many further applications to machinery, subject to sudden strains and violent jerks. In some cases moving fulcra might be advantageously substituted for pivots, so that the effect of the strain instead of being confined to one point would be distributed over some space. In the engines of war where the destructive effects of great forces acting instantaneously have often to be provided against, this method may be found useful in many other cases besides that in which it was first and so successfully employed.

This curve being of the family of spirals has an infinity of convolutions. Consequently the rack to govern a moving fulcrum may be of any length or at any distance from it.

To illustrate the application of a rack of this form; were it fixed to any circle a pinion at the height p from the ground-line would roll the circle along it, or if the circle was the moving power as it rolled it would revolve the pinion.

The manner in which this curve has been obtained has caused the rack to be sometimes called cycloidal. But this is a confusion of thought, as the cycloid is generated by a point fixed on the rolling circle, this curve by a point in the wall against which the circle rolls.

A small instrument by which this curve in its various cases may be freely drawn has been devised. It consists of a simple artifice by which a ruler carrying a movable pencil is kept always perpendicular to a thread unwound from a circle.

It will be remembered that the Moncrieffian curve is the locus of the extremity of a fixed length taken on the tangent to the involute of a circle: now the involute continually approximates to its tangent, for its radius of curvature is continually increasing up to infinity, hence it follows that all Moncrieffians derived from the same circle are asymptotic to the involute, and consequently to each other.

The length of the arc of a convolute or Moncrieffian curve, reckoned from the apse, when $\rho = d$ as calculated by Gentleman Cadet Lloyd, of the Royal Military Academy, is as follows:—

$$S = \frac{\sqrt{(\rho^2 - d^2)}}{2a} \sqrt{(\rho^2 + a^2 - 2ad)} + \frac{(a-d)^2}{2a} \log \frac{\sqrt{(\rho^2 - d^2)} + \sqrt{(\rho^2 - 2ad + a^2)}}{a - d} \,..$$

The portion cut off by the circle is therefore

$$(a - d) \left\{ \sqrt{\frac{2(a + d)}{a}} + \frac{a - d}{a} \log \frac{\sqrt{(a + d)} + \sqrt{(2a)}}{\sqrt{(a - d)}} \right\},$$

which vanishes as it should when $a - d = 0$, or $a + d = 0$.

When $d = 0$, (the case of Archimedes spiral) the intercepted arc is

$$[\sqrt{(2)} + \log\{1 + \sqrt{(2)}\}]\, a.$$

THE ABYSSINIAN EXPEDITION.

BY LIEUTENANT E. F. CHAPMAN, R.H.A.

The important position the Abyssinian expedition must hold in the future history of mountain warfare will, I trust, render a slight sketch of this military enterprise acceptable to the Regiment.

While, to us as artillerymen, it has afforded opportunities of witnessing the facility with which heavy mortars and field guns can be carried over 800 miles of mountainous country and of putting to practical test, a new description of mountain gun, it has added much to our experience, in connexion with all the different branches of the service, and should have gained for us, by contact with obstacles of no ordinary character, a confidence and practice in the conduct of hill campaigns which may hereafter prove of great service.

Though no opposition was met with on the march to Magdala, beyond the formidable barriers with which nature seemed inclined to bar our passage, the movement of a body of troops, large enough to ensure success, to a distance of 400 miles from our base of operations, and the happy termination of so difficult an undertaking, are successes which seldom fall to the lot of a commander.

A small force landed at Zulla early in October, as pioneers to the expedition. Expecting to find water, they had brought but a small supply with them, and no means existed for bringing this from the ships, so that an early move was made to the foot of the Koomaylo Pass, 14 miles distant. They were here separated by 50 miles from the Abyssinian Highlands, and it was by slow degrees only that the bed of the mountain torrent through which their road lay, could be made practicable; whilst this was being done, the cavalry took up a position on the bed of the Haddas river ten miles distant, supplies being conveyed from the shipping to both points by mule carriage.

One Company Native Artillery,
One 12-pr. howitzer,
One old-fashioned bronze 4$\frac{2}{5}$-in. gun,
Two 4$\frac{2}{5}$-in. mortars.
10th Regiment Bo. N.I.
3rd Regiment Bo. Light Cav^{y}.
Bombay Sappers.
One Company Marine Battalion.

From the first, difficulty was experienced in the lack of direct telegraphic communication with Aden and Suez; more troops were forwarded from Bombay before the preparations for their reception were completed, whilst the stores most urgently required were not those that first found shipment either at Bombay or Suez. Mules arriving without saddles, in the keeping of a ruffianly band of muleteers, hurriedly collected in Egypt and elsewhere, were either lost or stolen, or died from the want of ordinary care in watering and feeding. African glanders, the disease most to be dreaded, set in, and under such circumstances could ill be coped with.

Through the month of November there were few hands to unload the ships, though the navy were actively employed; yet a great deal was done by the small body already landed: a pier formed of rough stones brought from the other side of the bay in native boats was commenced and advanced several hundred feet into the water, under the superintendence of Captain Goodfellow, R.E., and admirable store sheds were constructed. The Tekondah Pass was surveyed, and our advance by the Koomaylo Pass to Senafé being determined on, every effort was made to improve that road. During the first week in December the stations in the Pass were in the occupation of detachments of the Pioneer Force, and the cavalry and native artillery were moved to Senafé; the former had already suffered much, and the mortality amongst their horses continued even upon the Highlands.

During November the equipment of the "A" Steel Battery under Lieut. Nolan reached Zulla, followed on the 12th December by that of "B" Battery, under Lieut. Chapman. The 10th Company, R.E., landed on the 10th December, and some three or four days later, the Scinde Brigade, under Brigadier-General Collings, arrived in the harbour, Sir Charles Staveley, K.C.B., having by this time assumed the command.

"G" 14th R.A.,
33rd Foot,
27th Bo. N.I. Beloochees,
Scinde Horse.

The difficulty of supplying water for the animals already received had become excessive, yet by working the condensers on board the ships and conveying the water in small boats and lighters, to tanks placed just above the high water line, a tolerable supply was pumped twice a day into the drinking troughs; the slight fluctuation of the tide in the harbour allowed of this system being at a later date brought to great perfection, when shore condensers were established, one at the end of the pier, and another on an artificial island near the trough.

It is almost impossible to describe the condition of the Land Transport Corps at this time! Hundreds of animals arriving were landed, but non-commissioned staff and muleteers could not be procured, whilst there were no interpreters to enable the officers to communicate with the few of the latter already under their orders. Spite of the efforts of individual officers, large numbers of mules strayed or were taken to Massowa for sale by deserters from the corps, while, of those tied up in the transport lines, but a small proportion could be led to the troughs, and many were in want of food; the placing of baggage animals under regimental care and the supply of 200 mules to the mountain batteries brought but small relief.

Thus early in the expedition no one seemed to have realized the full importance of tranferring our main depot from the coast to the highlands at Senafé, nor, with the mortality then raging, could any one master the difficulty, which arose from the weight of grain it became necessary for each mule to carry for his own consumption during a march of eleven days, five of which were occupied in the return journey. I am sure that the introduction of what was known as the "through system" instead of the establishment of depots in the pass and the supply by stages lay at the root of the matter, the latter plan admitting of the care of a much larger number of animals by the few men then available.

Something too might have been done by the temporary employment of a European regiment with the Land Transport Corps, while the fatigues of road making, &c. fell upon the native force.

During December the conveyance of stores from the pier and many such duties fell upon a corps of doolie-bearers from Madras; the arrival of camels and their employment in the transport to Koomaylo took place during this month. In the beginning of January the force at Zulla was increased by the following troops from Bombay:—3/21st R.A., 5/21st R.A., 4th K.O., 25th Bo. N.I., 3rd Bo. NI., Madras Sappers (from Madras).

The 33rd Foot was then pushed up to Senafé, and the detachments of the pioneer force in the passes relieved, these being assembled on the highlands.

The arrival at Zulla of H.E. the Commander-in-Chief on the 3rd January threw new life into the expedition, and during the remainder of the month the most strenuous efforts were made by the reduction of the baggage of the troops, &c. and the pressing of every available animal for the work to throw supplies into Senafé,—camels were procured from Aden and Berbery, and later on from Egypt (those from Berbery however being milch camels suffered much in carrying loads), and pack bullocks received from India were pushed up the Pass, while native carriage, consisting chiefly of small cattle and donkeys, was largely employed.

I would here mention the very important work carried on at Zulla from the commencement of the expedition with draught bullocks and light Bombay carts.

Though the employment of camels in the Pass, especially during wet weather, caused a great sacrifice amongst these animals, and no small difficulty in the mule transport, yet, no doubt it was necessary, and throughout the months of January and February, they formed a large part of the transport; the Maltese carts, however, drawn by two mules, were brought into play as soon as the road was reported practicable, the average load being about 6 cwt.

23rd Punjab (Pioneers) N.I.,
21st Punjab N.I.,
45th Foot,
2nd Regt. Bo. (Grenadiers) N.I.,
18th Regt. Bo. N.I.

The arrival of a portion of the Bengal Brigade, during the early part of January, and at the end of the month, the formation of a Naval Rocket Brigade,* and arrival of 5/25th R.A., from Calcutta, and 3rd Brigade from Bombay, compelled the movement of additional troops to the highlands on account of the difficulties of water supply. Fortunately the admirable arrangements for conservancy and the temperate climate of Zulla up to this time, allowed this much to have been done with but a moderate sick list. A second pier of timber had meanwhile been constructed, the first being perfected to a length of 400 yards; the railway had been pushed forward five miles, where the 23rd Pioneers employed on the line afterwards discovered good water at a depth of 60 or 70 feet.

On the departure of the Commander-in-Chief and staff at the end of January, there remained only "B" Mountain Battery, 5/21st R.A., Naval Brigade, 21st and 23rd Punjab N.I., wing of the 4th K.O.

This force was increased shortly afterwards by the 12th Bengal Cavalry, and at the beginning of March by the 10th Bengal Lancers, and 3rd Dragoon Guards from Bombay; the 26th Cameronians being called for

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* 7 Officers, 93 men; 12 rocket tubes, 80 rockets per tube 6-pr.

as our line of communication extended. The arrival of the last-named regiment prevented the employment of a second Naval Brigade, already formed and landed. The 5th and 8th Bo. N.I. were also sent for, but arriving at Zulla after the fall of Magdala, they were ordered to return to Bombay without disembarking. The fatigue and other duties at Zulla were taken by the 2nd and 18th Bo. N.I. till the close of the campaign.

I am unable to detail the various corps of dooley-bearers, coolies, &c. brought into use with the force.

Early in February Addigerat, the principal town on the outskirts of Tigré, three marches from Senafé, which just comes within that province, was occupied by the 33rd Regiment, a wing 10th N.I., "A" Mountain Battery, 3/21st R.A., 3rd Cavalry (Bombay).

The good will of Kassa, Prince of Tigré, was secured, and the regular advance of the army from its base commenced.

Referring to G.O.C., Head Quarters, Zulla, 23rd January, 1868, and 23rd February, it will be observed how soon the baggage of the army was reduced and the scale of ration diminished.*

Before the head-quarters had passed Senafé, G/14th R.A., under Captain Murray, was ordered from Koomaylo, where the battery had been stationed since arrival. The guns were taken up in bullock-draught through the difficult passage of Sooro to Senafé, the horses having been previously sent to the highlands to avoid the prevalent disease; the bullocks then returned to Koomaylo, and three wagons were brought up and placed at Senafé in reserve. Three wagons of the first line, and those of the second line were left in the ordnance park at Zulla. A portion of the wagon ammunition was taken on to Addigerat in treasure boxes. The guns and limbers arrived safely at that place drawn by horses. A detachment of two guns of the battery under Captain Lluellyn remained in the entrenched camp throughout the expedition, four guns being present at Adabagah on the 16th February, where an interview took place between Sir R. Napier and Kassa, Prince of Tigré. Meanwhile, the advanced brigade had pushed on to Antalo, arriving on the 20th February, and on the 26th the Pioneer Brigade, with Colonel Phayre, Dept.-Qr.-Master-General, left to survey and open out the road towards Ashangee.

The head-quarters, with G/14th, the 4th K.O., &c. only reached Antalo by the 1st March.

The arrival of 41 elephants during the month of January led to the formation of a mortar battery of two 8-inch mortars, under Major Hills, **VC**, eight elephants being devoted to the carriage of mortars, beds, and ammunition, with a proportion of mules. These left Zulla on the 23rd February, 27 elephants accompanying the above for the conveyance of the guns of G/14 R.A. along the difficult mountain roads towards Antalo, the remainder being spare.

On the 28th February the troops of the 1st Division remaining at Zulla received orders to push forward to Antalo, and owing to the difficulties encountered by the pioneer brigade, arrived there in time to join in the general advance from that place between the 12th and the 16th March.

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* Vide Appendix, pp. 187, 188.

These were: "B" Battery Mountain Train, 5/21st R.A., 23rd Punjab Pioneers, Naval Brigade, 12th Bengal Cavalry.

The arrival of Sir R. Napier at Senafé had been preceded by the movement of the larger portion of the transport mules, especially those of the Lahore and Rawul Pindee trains, to the highlands, and it was with the greatest difficulty that carriage was found for the troops ordered up. 1500 animals were at this time left in a sick depot at Focada, where glanders was raging.

The superior organization and condition of the Punjab Transport Corps over the divisions formed at Zulla could not fail to attract attention.

The whole of the troops of the Bengal Brigade, under Brigadier-General D. M. Stewart, arriving with every arrangement for transport, were ready to march immediately after landing. The superiority of the Bengal system over that of the Bombay Native Army and the better *physique* of the Punjabees has been maintained throughout the campaign.

G. O. C. C.

Adjutant-General's Office.

Head Quarters, Camp Antalo,
4th March, 1868.

The following distribution of troops comprising the Abyssinian Expeditionary Force is ordered:—

1st Division.

The whole of the troops from Antalo to the front will compose the 1st Division.

Major-Gen. Sir Charles Staveley, K.C.B., to command,	Lieut.-Colonel Wood, Assist.-Adjt.-Gen.;
	Major R. Baigrie, Assist.-Qr.-Mr.-Gen.

Pioneer Force.

To march two days in advance of the 1st Brigade, 1st Division.

Brigadier-General Field, to command,	Lieut. Shewell, Commissariat Officer,
Captain Durand, Brigade-Major,	Captain Goodfellow, Field Engineer,
Captain Macgregor, D.-A.-Q.-M.-G.,	Lieut. Jopp, Field Engineer.

Colonel Phayre, D.-Q.-M.-Gen., will accompany the pioneer force and survey the road and the country in its immediate neighbourhood.

Troops.

40 Sabres 3rd Light Cavalry,	2 Companies 33rd Foot,
40 Sabres 3rd Regiment Scinde Horse,	2 Companies 27th N.I. (Beloochees);
3rd and 4th Companies Bombay Sappers and Miners,	1 Company 23rd Punjab Pioneers.

1st Brigade, 1st Division.

Brig.-General Schneider, to command,	Captain Hogg, D.-A.-Q.-M.-G.,
Captain Beville, Brigade-Major,	Major Mignon, Commissariat Officer.

Troops.

Head-Quarters, Wing 3rd Dragoon Guards,
3rd Regiment Light Cavalry,
3rd Regiment Scinde Horse,
"G" Battery, 14th Brigade, R.A. (4 guns),
"H" Battery, 21st Brigade, R.A.,
4th King's Own Regiment,
Head-Qrs. and 8 Companies 33rd Regiment,
Head-Qrs. 10th Company, R.E.,
Head-Qrs. and 2 Companies 27th N.I. Beloochees,
Head-Qrs. Wing 10th Regiment N.I.

2nd Brigade, 1st Division.

Brigadier-General Wilby, to command,
Captain Hicks, Brigade-Major,
Captain Fawcett, D.-A.-Q.-M.-G.,
Major Bardin, Commissariat Officer.

Troops.

Head-Quarters Wing 12th Bengal Cavalry,
"B" Battery, 21st Brigade, R.A.,
Two 8-inch mortars with detachment 5/25 R.A.
Rocket Battery, Naval Brigade,
"K" Company, Madras Sappers,
Head Qrs. and 7 Companies 23rd Punjab Pioneers,
Wing 27th N. I. (Beloochees).

2nd Division.

Major-General Malcolm, C.B., Commanding,
Major G. Bray, Assist.-Adjt.-Gen.,
Captain Watts, D.-A.-Q.-M.-G.,
Major Leven, Assist.-Com.-General.

All troops to and from Senafé to Antalo will compose the 2nd Division.

Antalo Garrison.

Brigadier-General Collings, to command,
Major Quin, Brigade-Major,
Captain James, D.-A.-Q.-M.-G.,
Lieutenant Hore, Commissariat Officer.

Troops.

Wing 12th Bengal Cavalry,
5/25th R.A.,
Hd.-Qrs. and "H" Company Madras Sappers,
45th Foot,
3rd Regiment N.I.

Addigerat Garrison.

Major Fairbrother, to command,
Squadron 10th Bengal Cavalry,
2 guns, 8/14th R.A.,
Head Quarters and 2nd Company Bombay Sappers,
Wing 25th N. I.

Senafé Garrison.

Lieut.-Colonel Little, 25th N. I. to command,
Lieut. Becke, Staff Officer,
Capt. Edwardes, D.-A.-Q.-M.-G.,
Major Thacker, Commissariat Officer.

Troops.

1 Squadron 16th Bengal Cavalry,
1 Company Native Artillery,
3 Companies 21st Punjab N.I.
Wing 10th N. I.,
Detachment 21st Bombay N. I. or Marine Battalion,
Head-Qrs. Wing 25th N. I.,
Depots of all Regiments in advance.

Zulla Command.

To be composed of all troops at Zulla and the stations in the passes.

Brigadier-General Stewart, to command,
Captain Fellowes, Brigade-Major,
Major Roberts, Assist.-Q.-M.-General,
Major Gammell, D.-A.-Q.-M.-G.,
Captain Hawkes, Commissariat Officer.

Troops.

1 Squadron 10th Bengal Cavalry,
"G" Company Madras Sappers,
1st Company Bombay Sappers,
2nd Regiment N. I. (Grenadiers),
18th Regiment, N. I.,
Head-Qrs. and 5 Companies 21st Punjab N.I.

"Second Reserve" ammunition of every corps and battery ordered now and hereafter to Antalo to be sent to that post. The remainder of the ammunition to be detained at Senafé.

2nd Reserve.

Snider ammunition, 250 rounds per rifle,
Musketry ammunition, 150 rounds per rifle,
Carbine ammunition, 100 rounds per carbine.

To avoid confusion, I may here record the names of the different halting grounds between Zulla and Antalo,—

Zulla,
Koomaylo,
Sooro,
Undul Wells,
Rayray Guddy,
Senafé,
Goonagoona,
Focada,
Addigerat,
Mai Wahiz,
Adabaga,
Dongolo,
Agoola,
Dolu,
Eikhullut,
Antalo.

Total distance is 192 miles. The road rising in the first five marches to an altitude of 7500 feet, and then passing over a succession of rugged hills several hundred feet high to Antalo 7200 ft. high. Fortunately, with the exception of the troops already detailed as garrisoning Addigerat, Senafé, and the stations in the Pass, the minor posts could be held by small parties of cavalry, only sufficient to keep up a tolerably efficient postal service.

By this time the powers of the Transport Corps were so far exhausted that the stream of supplies from our base of operations must have ceased, had not General Malcolm set on foot a system of native carriage between Addigerat and Antalo, which though unequal to our enormous requirements continued to work throughout the expedition. Thus then, with the exception of a small commissariat supply, the duties of our Transport service were limited to the carriage of baggage, ammunition, and treasure, and starvation would have stared the army in the face, if at Antalo, the resources of the Valley of the Teckazee, to the westward, had not been opened out to us, firmly secured by the brightness of our dollars.

At this very period 150 vessels were afloat in the harbour of Zulla, while stores, that many even then would have deemed luxuries, lay stacked upon the shore.

The following detail of ships chartered thus early at the different ports undermentioned, proves the correctness of this statement:—

	Steamers.	Sailing vessels.	Total tonnage.
Bombay	32	159	179,405
Calcutta	15	24	37,876
England, *viâ* the Cape...	12	—	27,157
Suez	8	—	6733
Aden	—	1	840

69 native bugalows.

Excluding the carriage of troops and animals, and the tonnage occupied for hospital accommodation, &c. a liberal margin remains for stores and supplies, from which the army could derive but small benefit.

Here then our Commander might have failed in the courage which was required to push forward an army 200 miles further into a difficult country, the resources of which it was impossible to estimate; or he might have been tempted to diminish the Force he considered necessary to operate against a formidable stronghold in the hands of a desperate enemy, and to maintain a line of communication equal in length with that by which he was already separated from his base.

The Pioneer Brigade had not made three marches from Antalo, when an easier road to Atala than that they had selected was discovered; along this the Division advanced, moving thence forward as it were without a Pioneer Brigade, in single file along difficult mountain tracks, rising several times to an altitude of more than 10,000 feet above the sea level. Of the three columns, the rear comprised the guns of G/14th R.A. carried on elephants, two 8-inch mortars, 12th Regt. of Cavalry, and "K" company of Madras Sappers, wherever they were joined with other troops, the slow and difficult march of the elephants served to impede the column.

Halting grounds.
Antalo,
Musgee,
Meeshek,
Atala,
Mukhan,
Ashangi.

On this side of Atala the army passed the Amba of Waldoo Yasus, an independent chief, claiming protection from Theodore against Kassa. He afterwards proved troublesome in disturbing our arrangements for native carriage and in indulging in petty squabbles with a brother-in-law of Prince Kassa, but being submissive on our return was left uninjured. The mountain lake of Ashangi, at an altitude of 8200 feet, is 17 fathoms in depth, its extent being five miles by four. It lies on the border of the territory of Wofela; here the Mahomedan population of the Gallas is mixed up with a Christian element, and constant disturbances take place from the near neighbourhood of two antagonistic races.

G. O. C. C.

Adjutant-General's Office.

HEAD QUARTERS, CAMP DILDEE,
25th March, 1868.

The following distribution of troops in the 1st, or Sir C. Staveley's division, is ordered:—

Troops, 1st Brigade.

Hd.-Qrs. 3rd Scinde Horse, to be completed by the detachment, *en route* to join,
"A" 21st, Steel Battery,
1st Battalion, 4th K. O.,
Hd.-Qrs. and 6 Companies 23rd P. Pioneers,
Hd.-Qrs. Wing 27th N.I.

Troops, 2nd Brigade.

Hd.-Qrs. 3rd Light Cavalry,
"B" 21st, Steel battery,
Naval Rocket Brigade,
33rd Duke of Wellington's Regiment.

Troops, 3rd Brigade.

Four guns, "G" 14th, R.A.,
No. 3 and 4 Companies, Bombay Sappers and Miners,
Two Companies Punjaub Pioneers,
Two 8-inch Mortars of 5/25th R.A.,
"K" Company Madras Sappers and Miners.

A company of 33rd Foot, and a company of 4th K.O. who will hereafter rejoin their corps when the brigade is more advanced to the front.

The following troops *en route* to join will be passed on (on reaching the 3rd Brigade) to join the 1st and 2nd Brigades:—

Hd.-Qrs. 3rd Dragoon Guards.
Hd.-Qrs. 10th Bengal Cavalry.
Wing 45th Foot.
Wing 3rd Native Infantry.
Wing 27th Native Infantry.
Hd.-Qrs. & 1st Co. Bombay Sappers & Miners.

The kits of officers, n.-c. officers, &c. will be left behind to be brought on by the 3rd Brigade.

Tents will be allowed in the proportion of one to every twelve officers, and one to every twenty n.-c. officers, &c.

Major-Generals commanding divisions will be allowed one tent.

Brigadier-Generals, one tent for themselves and their personal and brigade staff.

Hospital tents will be allowed to each regiment, battery, or detachment, according to the recommendation of P.M.O. with that exception no other tents must be taken for any purpose whatever.

A light hospital establishment to accompany each detachment.

All sick men and horses will be left behind.

Fifteen days' ration, according to the following scale, to be carried:—

Europeans.		Natives.	
Biscuit or flour	1 lb.	Flour	1 lb.
Vegetables	2 oz.	Ghee, if purchased locally	2 oz.
Sugar	1½ oz.	Salt	½ oz.
Tea	½ oz.	Vegetables, once a week	2 oz.
Rum	1 dram.		

Officers will be allowed to take on any riding animals they may have in their possession, but their loads must be limited to the officers own bedding and their horse's kit.

No private baggage animals, or camp equipage of any description will be allowed to follow the column under any pretext whatever.

Carriage will be allowed for cooking pots of officers, in the proportion of one mule to every twelve officers.

No baggage mule proceeding with the Force will carry more than 100 lbs. excepting in the case of boxes of small-arm ammunition and tents.

Cooking pots of batteries and detachments in the proportion of 50 lbs. to each company or troop.

British troops will march in serge or Khakee clothing (the suit of clothing which is not worn will be carried by the soldier), and will carry the blanket and waterproof sheet in addition to the greatcoat and canteen.

Officers who do not possess a riding animal will have two blankets and a waterproof sheet carried for each, mules being provided under regimental arrangements.

Sick carriage will be taken on as at present allowed; all doolies, however, will follow in rear of the whole baggage of the brigade.

One man, inclusive of muleteers, will be told off to every mule, to lead him during the march.

Though it was intended that our baggage should follow us to Magdala, the 3rd Brigade was quickly broken up, and from the 24th March until the 29th April, the army remained without baggage, marching under the arrangements herein detailed. At the same time the scale of ration laid down could not be complied with, and the troops were for the greater part of the time without rum, sugar, or vegetables.

Halting grounds.
Ashangi,
Musgeeta,
Lat,
Marrowah,
Dildee,
Moojah,
Teckazee.

The advance to the Teckazee was necessarily slow from the size of the different columns, and the very difficult nature of the country. A depot was formed at Dildee, and it was in light marching order that the ascent to the plateau of Wadela (altitude 10,600 feet), was made; the whole force being once more collected at Santara. We had been for some days in the territory of the Wagshum Gobezai whose uncle Jeddah Museecha here visited the camp with a body of light horse, whose riding and manœuvring excited surprise.

Halting grounds.
Santara,
Gazoo,
Abdicoom,
Scindee,
Betchor,
Talanta.

The force started from Santara on the 31st March. Magdala was now supposed to be near at hand, but we learned to appreciate the common remark of the soldiers that "Magdala was upon wheels." The table land of Waddela however resembling in the character of its scenery and in its climate, the highlands of Thibet (our thermometer stood as low as 19° at night) afforded a pleasant change in our style of marching.

On the 4th April a depot for sick was formed at Scindee, a reserve of ammunition being brought up to that place.

At Bethor we found ourselves upon the King's road from Debra Tabor to Magdala, and were indeed glad to avail ourselves of this well constructed highway in the formidable descent (3000 ft.) to the chasm of the Jeddah. The labour of surmounting the corresponding ascent to the Talanta plain, made us respect the energy of the "Mighty Negus" who so recently had dragged his heavy ordnance along this route.

The plateau at this point, enclosed between the Jeddah and the Beshilo, is about five miles broad; from its southern edge we plainly distinguished Magdala at a distance of about eleven miles.

Until the 8th the force was detained awaiting the arrival of the 45th Foot, but on the 9th the whole division was brought together before making the descent to the Beshilo. The 3rd Dragoon Guards only arrived on the 12th.

The original intention with regard to the distribution of the reserves had not been carried out before the conclusion of the campaign, though depots were formed at Senafé, Antalo, Dildee, and Scindee. 400 rounds per rifle were however forwarded to Senafé, while 200 rounds accompanied the troops.

Of the artillery reserve, the steel batteries were accompanied by their first reserve, 5500 rounds per battery remaining at Zulla. 702 common shell, 283 case, 889 segment shell, belonging to G/14th R.A. were retained at the same place, with 200 rounds for each of the 8-inch mortars.

A large proportion of shell was early forwarded to the highlands for these pieces, and some 50 rounds of common shell were destroyed on the return march to save carriage. I have already mentioned the detention of three wagons of G/14th R.A., with reserve ammunition at Senafé.

Some explanation of Theodore's position, if given here, may throw light on subsequent operations. A group of three flat-topped hills occupied by the enemy formed an indented isosceles triangle, of which the two sides were 3000 yards long and the base something over 4000 yards. The hill of Magdala, the apex of this triangle, was concealed from view by those of Islamgee and Falla, which formed the base, the former being on the right. A high rock of basalt, named Selassee, rose from the centre of Islamgee to a height of 450 feet, while the front of the hill itself occupied 1620 yards. Falla on the left is a natural bastion with faces of 450 yards, and flanks of about 60 yards.

Magdala and Islamgee are connected by a saddle about 1200 yards long, while a second saddle of 700 yards joined Islamgee to Falla.

The King's road running under Falla on the northern side, crossed this last saddle, and passing below the scarp of the first, mounted it, and rose almost directly to the gate within 200 yards of the base of the Magdala hill.

The top of the Selassee, 3870 feet above the bed of the Beshilo, commanded the crest of the Magdala hill by 100 feet, while the gate was placed some 70 feet down the face of the hill, whose extreme height was 390 feet. The saddle below Magdala was 70 feet higher than that between Islamgee and Falla, and this last was 900 feet above the plateau of Arogee, which descended 276 feet in a length of 1¼ miles. The descent of the Arogee Pass was 444 feet, and a drop of 1500 feet further was made in reaching the Beshilo. Our position on Talanta was 3500 feet above the river, and the road down was precipitous; recent rain had brought the stream to a depth of 2½ feet.

Adjutant-General's Office.

HEAD QUARTERS, CAMP NORTH BANK OF BESHILO RIVER,
8th April, 1868.

The following Memoranda of Instructions for guidance of Officers during the attack on Magdala, are published :—

1. British infantry on the day of the advance on Magdala will wear Khakee clothing.

2. Each man's greatcoat, blanket, waterproof sheet, and serge clothing will be made up into roll and packed in sulleetah in proportion of twelve bundles to one mule. Requisitions for sulleetahs must be made out on the day previous to the advance, and they must be packed ready and piled in separate heaps by regiments on spots which will be pointed out by the D.-A.-Q.-M.-General of the Brigade.

3. Two pounds of biscuit and two pounds of cooked meat will be carried by each British officer and n.-c. officer on the morning of the advance. Native soldiers will be served out with parched grain or cooked meat and chupatties.

4. Regimental cooks will remain at the depot in rear, and if the operations against Falla or Islamgee last more than one day, they will, day by day, cook the requisite number of rations for their respective corps, which will be forwarded under Land Transport Corps arrangements to the front.

5. Every foot soldier will cross the Beshilo river bare-footed. They must be directed to fill their water canteens at the river before advancing, and warned of the necessity of husbanding it during the early part of the day.

6. A proportion of water-carriers will accompany each brigade in rear of the column; two-thirds at least of the hand-bheesties should follow the attacking force; the officer in charge of this corps will see that each regiment and battery is duly supplied with drinking water during the attack whenever an opportunity offers itself.

7. The reserve ammunition of regiments will be placed in charge of a captain of the Land Transport Corps; forty rounds per man will follow in rear of the attacking force under quarter-masters of regiments. The remainder will be divided into two parts, one half will be in rear of the supporting column, and the remainder with the reserve. When a commanding officer finds his ammunition running short, he will send an officer to the rear with a written order for as many boxes as he requires. Directly ammunition is sent to the front from the supports it must be replaced as soon as possible from the reserve.

8. Every staff officer and officer in independent command will provide himself with a certain number of slips of paper of convenient size, as also a lead pencil. All orders conveyed to staff officers by word of mouth must be written down by them and read to the officers sending them before being despatched; all written orders received by officers in independent command must be acknowledged shortly in writing and sent back by the staff officer who brought them.

9. Orders conveyed to batteries of artillery should invariably be sent through the officers commanding the two artillery divisions, so as to ensure their not being misunderstood.

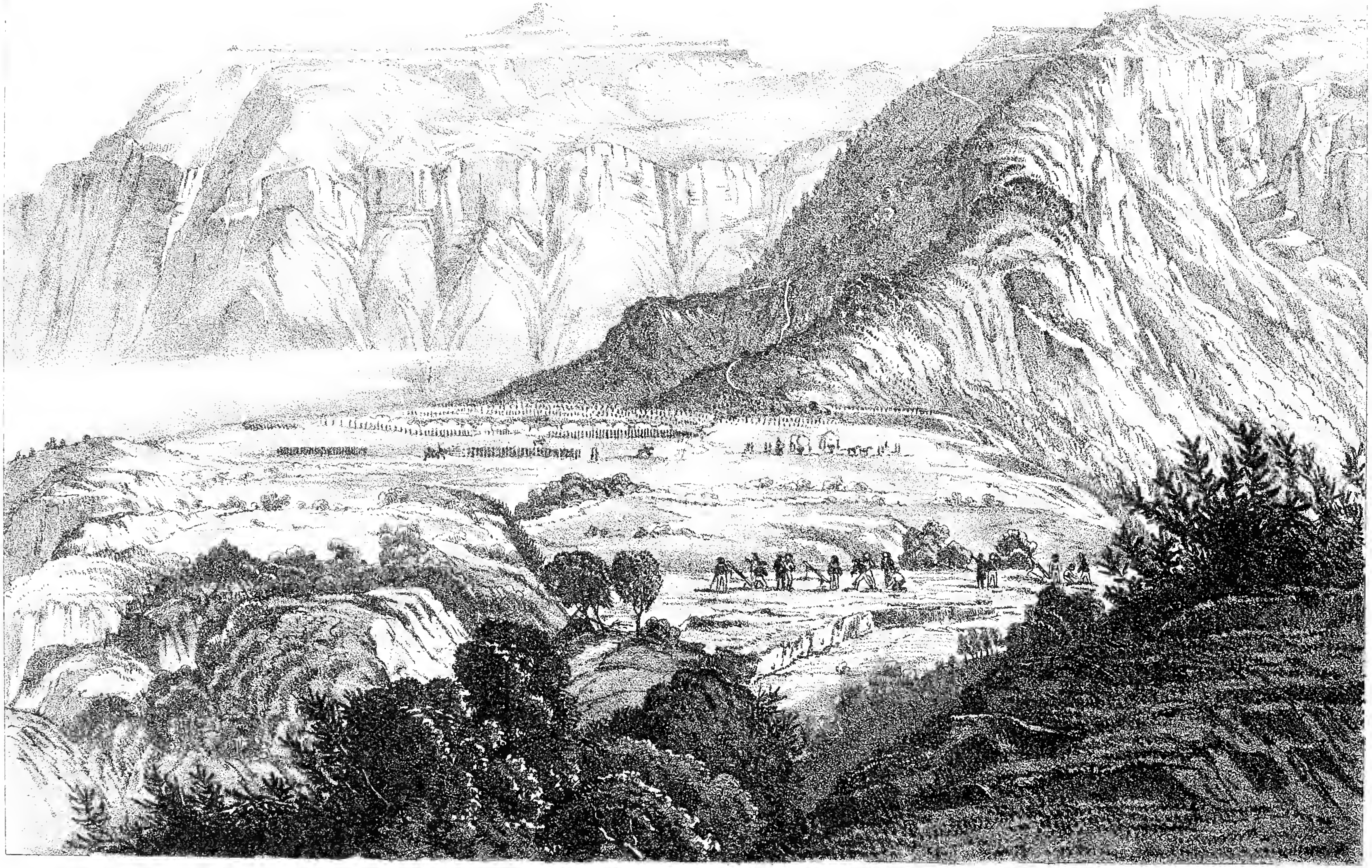
10. No one belonging to the attacking force must be allowed to fall out for the purpose of assisting a wounded man. An hospital corps, consisting of bandsmen, spare drummers of regiments, and a proportion of Punjab muleteers will be formed under command of a captain. They will have in charge all the stretchers and "dandycots" told off in a proportion of four to each; the men of this corps will march in rear of the attacking force and will convey wounded men to a spot in rear, which will be pointed out by the Inspector-General.

11. Every effort should be made to prevent soldiers wasting their ammunition. The necessity of taking a cool and steady aim must be explained to them on parade, and when in action officers and non-commissioned officers must exert themselves to ensure their doing so.

12. Mounted officers will be allowed one spare charger, which will remain in rear of the supporting column; horses in excess of this number will remain with the reserve.

13. Directly the force is in possession of Falla and Islamgee, tents will be brought up from the rear by elephants.

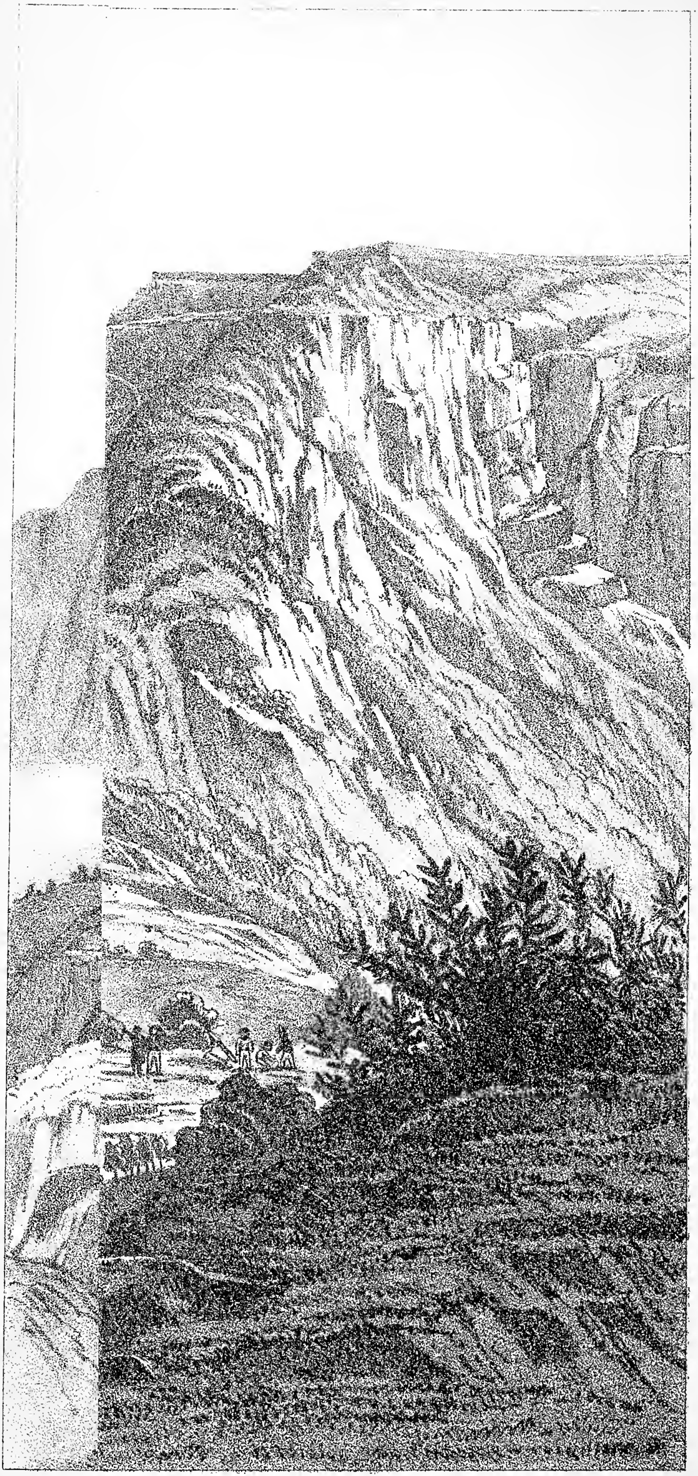
On the 10th April (Good Friday) the 1st Brigade descended to the Beshilo at daylight, the 2nd Brigade following at 10 a.m. From the Beshilo Sir C. Staveley, K.C.B., made a reconnaissance in force with the 4th K.O., 23rd Pioneers, 27th Beloochees, 10th Co. R.E., and Bombay and



Lithographed at the Royal Artillery Institution

ACTION OF AROGEE.

Copied from a lithograph produced at the Topl. Depôt of the War Office.



Lithographed at the Royal Artillery Institution

Madras Sappers and Miners, moving by a difficult ascent to the plateau immediately above the river and on the right of the road to Magdala. "A" Battery, 21st Brigade, and the Naval Brigade, remaining behind at the river. At 1 o'clock an order was received for the artillery to advance by the road to the Pass of Arogee, which was reported to be in possession of our infantry. About 4 o'clock, as the artillery completed the ascent from the ravine by a steep zigzag; the 23rd Pioneers were sent from the plateau by the left to hold the road during their advance, the position designed for our camp lying to the right rear and above the road they ascended.

Hardly had the top of the pass been reached when the order was given "Prepare to receive the enemy." At this time Theodore opened fire from Falla with three 6-inch guns, and later, fired from a large (13-inch) mortar on Islamgee. His position having a command of 1200 feet, enabled him to obtain a range of 2400 yards, but with a plunging fire; the shot passing over the heads of the troops, took no effect. The enemy to the number of about 5000 now swarmed down the hill from Falla, making their way across the Arogee plateau and streaming from it to our left by a series of narrow ravines as they struck at our baggage which followed in rear of the artillery.

The battery came into action supported by the 23rd Pioneers and one Company of the 4th K.O., while the Naval Brigade, moving to a knoll on the right which commanded the plateau (where the Commander-in-Chief had stationed himself), a fire of shell and rockets was quickly brought upon the enemy. The 4th K.O., the Beloochees, and Bombay Sappers, supported by the 10th Co. R.E., advanced along the plateau, the Madras Sappers moving by the right to cut off a retreat by the valleys on that side. The Sniders quickly took effect, and some thirty bodies dotted the plateau before the regiments formed line to the left, pouring volleys into the enemy who were massed in the ravines on their flank, the 4th K.O. and Beloochees descending as they got further away. Meanwhile the rockets had played on the plateau, and the Naval Brigade advancing, took up a second position about 500 yards from the foot of Falla, which enabled them to drive out the enemy from a slight protection afforded by a turn in the road, and to throw their rockets into Falla itself, these projectiles causing great consternation. From the first the battery had been firing on the masses collected on the slopes to the left of the plateau with common shell and shrapnel as the range decreased from 1500 yards to 500 yards. As the infantry continued to drive the enemy into the ravines, they came still further under fire of the battery, which with the small arms of three regiments effected a great slaughter. Spite of our superiority it cannot be denied that their resistance was that of a brave people; though driven off the plateau, their advance was so well sustained that our baggage guard itself was closely engaged. At dusk the troops followed the enemy then retiring up the hill, two guns of the battery accompanying the 4th K.O., and two rounds of case were fired. The force was withdrawn at sundown, and lay under arms all night in the position originally occupied by the battery. As they were within range of the guns on Falla, a strict silence was maintained.

The supply of water was so scanty, that half a pint only was served out, and many received none.

The 2nd Brigade had meanwhile been sent for; leaving the Beshilo at 11 p.m., it occupied a position along the road about half a mile in our rear. Between 2 and 4 p.m. the troops of 1st Brigade were moved to the ground originally selected for camp; the 2nd Brigade retaining the position they then occupied. The whole of the division suffered much from want of water and provisions.

Orders to assault Falla were eagerly looked for, but shortly after sunrise a party under a flag of truce was observed descending the hill.

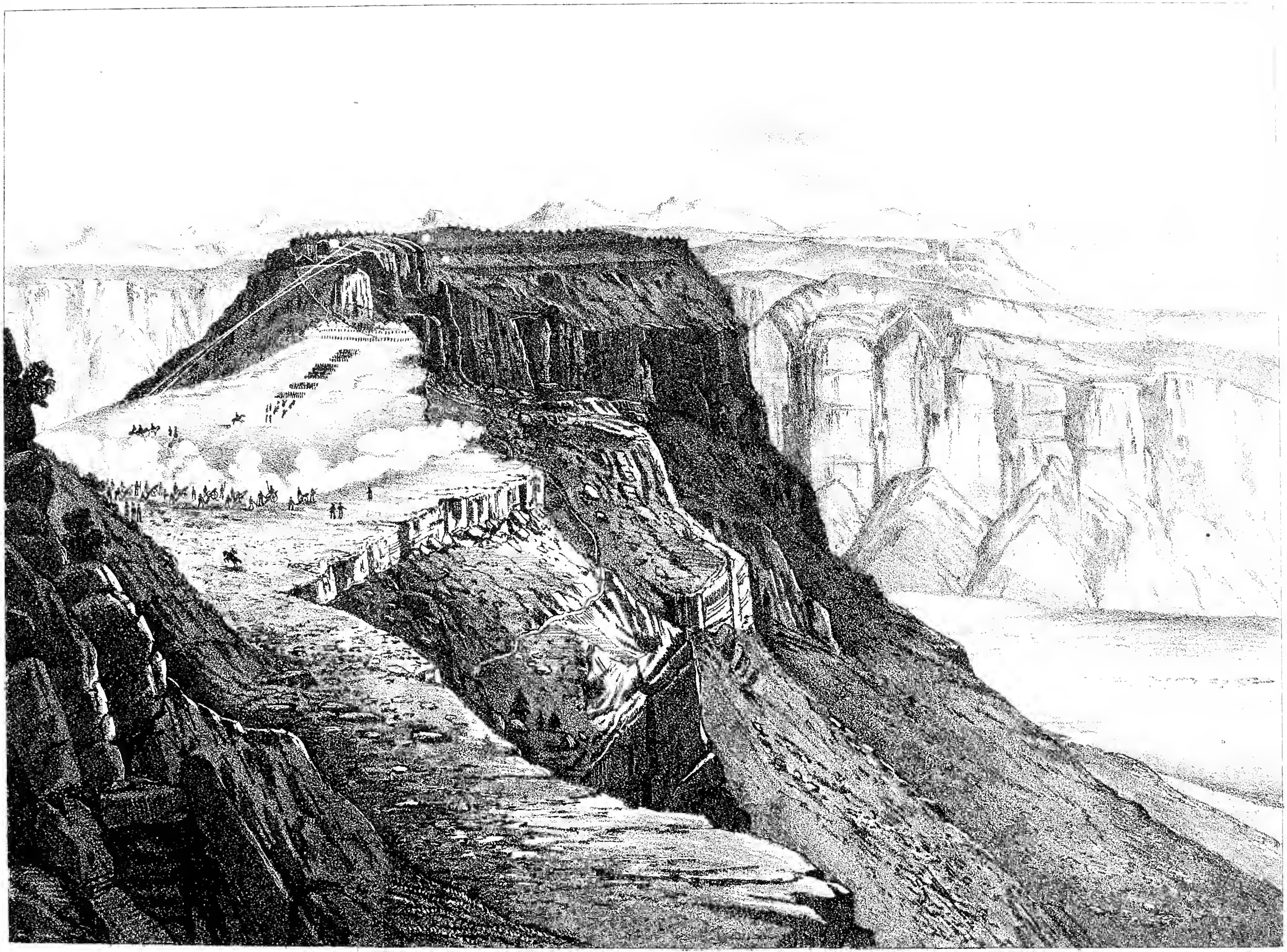
The death of Theodore's "leader of the vanguard" with 700 of his bravest troops, and the continued absence of very many of his followers, had so far humbled him that he had authorized Messrs Prideaux and Flad to make terms for him at any cost. Sir R. Napier sent him a letter to the effect "that he considered him a brave soldier, beaten rather by the superiority of our arms than through any fault of his own," but at the same time, he demanded an "unconditional surrender." The envoys, on their return found the mighty "Negus" sadly out of temper, and narrowly escaped his anger. He, however, again despatched them with a communication to this effect, "Who are you, the servant of a woman, that you should write to me?" Sir Robert's letter being returned.

He would then appear to have considered his case a hopeless one, and attempted suicide. As one of his chiefs turned the pistol he used to one side, his intention changed, and imagining himself reserved for a better fate, he determined to despatch the whole of the British prisoners to our camp. Messrs Prideaux and Flad returning with heavy hearts that evening with a message from Sir Robert "that his instructions precluded him from treating further until the whole of the prisoners were in our camp," did so under fear of their lives, but were overjoyed to meet their fellow captives (Mrs Flad excepted) on their way down the hill. At 8 p.m. the whole party were passed through our pickets, and the anxiety for their safety felt throughout the day was relieved.

Theodore felt so confident that by releasing our captives he would secure the good will of our chief, that on Sunday morning he sent a large present of cattle, &c. which was detained outside the pickets, but he shewed no symptom of surrender. During Sunday the guns of G/14th R.A. were brought up on elephants, and placed in position on the knoll occupied by the Naval Brigade on Friday. The 8-inch mortars were at the same time placed in rear of the 1st Brigade camp, and two steel guns formed a picket, covering the road communicating with the 2nd Brigade camp. On the 12th, the German artisans and their families were sent into camp, but Theodore refused to surrender, saying that "Child of man had never conquered him."

Early on the morning of the 13th, several chiefs came into camp and reported that Theodore had made an attempt to escape, but that failing to persuade his chiefs to follow him, he feared falling into the hands of the Gallas, who swarmed round Magdala, and had returned.

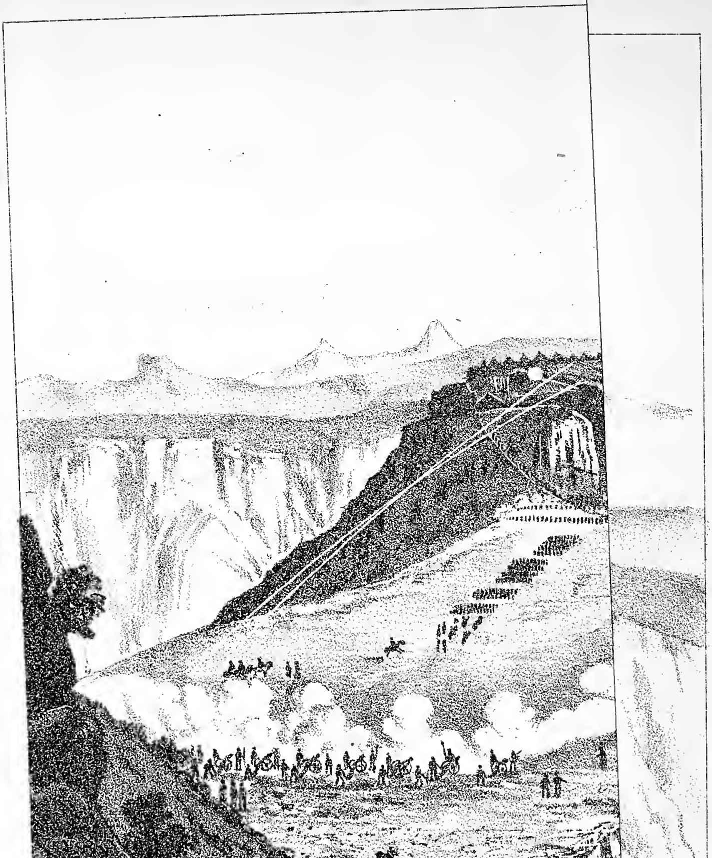
The division was then ordered to form on the plateau of Arogee, and the advance up the road to Falla commenced; a position for the Artillery in the event of an assault had been selected on Sunday. Four guns G/14th R.A. and the two 8-inch mortars from the foot of the hill could play on the saddle between Falla and Islamgee. The "A" Mountain Battery occupied a position at the end of a spur running out from Falla, some 500 yards up



Lithographed at the Royal Artillery Institution

THE CAPTURE OF MAGDALA.

Copied from a lithograph produced at the Top.l Dépôt of the War Office



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the road, while "B" Battery accompanied the column, which was formed in the following order:—

10th Co. R.E.
33rd Regiment,
"A" Co. Bo. Sappers,
"B" Batt., &c. &c.

A portion of the Beloochees and 10th Bombay Native Infantry were directed to swarm up the hill and occupy Falla.

Sir C. Staveley was accompanied by Messrs Wlademir and Flad as guides; no resistance was made, and the column ascended the slope of Islamgee; here the Bombay Sappers mounted a difficult scarp by the right, the 33rd with three guns of "B" Battery moving by the left; the guns were dismounted and carried by hand, and were finally brought into action on the top of Selassee, 2000 yards from the gate of Magdala; the remaining three guns took an easier road along the southern side of the slope, by which also the "A" Battery was advanced, the guns being brought to a position at the end of the saddle below Magdala, where they were joined by the three guns of "B" Battery from Selassee later in the day; G/14thR.A. the 8-in. mortars, and Naval Brigade were brought into action upon the road itself below the scarp; a 6-in. bronze gun and 10-in. mortar on travelling carriages were upon the road, the former having recently been withdrawn from Falla, the latter from Islamgee. The Cavalry in advance, a Company of the 33rd, and 10th Company R.E. occupied the enemy's park, the position afterwards chosen for our mountain guns, about 1300 yards from the gate. A few shots were exchanged at this point while the position was held during the formation of the division on Islamgee; the batteries being in position about 3 o'clock, the column of assault was formed about 4 o'clock, the 10th Company R.E. being in advance of the 33rd, the Madras Sappers following with scaling ladders, and the remainder of the division being in support.

Half an hour before the advance sounded, the batteries opened fire upon the gate, which was formed of a thick palisade, supported by a barricade of stones half-way up its height. Its roof was covered with earth and stones and a thick loop-holed defence touched it on the left, a difficult hedge running all along the ridge of a precipitous rock, presented an obstacle sufficiently formidable, but there was no flanking defence. Whatever may have been the number of warriors that accompanied Theodore into Magdala, there were very few that remained to hold the gate against a British army. The heavy artillery fire brought upon this point, previous to the assault is justified by the ignorance in which we remained to the last of the number of its defenders; it is at the same time certain that the effect of our shell prevented the 700 men who occupied Magdala, from joining in opposing our entrance.

It was some time before the gate gave way, and entrance was obtained in the first instance over the hedge, a scaling ladder was then placed against the earthwork by which the 33rd passed over. The warriors of the silver shield, few in number though they were, had died gallantly at their post. Theodore with his armour bearer sole survivors at the first gate, pushed up to the second gate by a steep and rugged path. Raised on a stone the king was seen to lift his hand as though in the act of cursing those who had hunted the lion to his den, and before a British bullet could lay him low, his own hand put an end to his existence.

The troops formed in Magdala at sunset; the Fort was occupied by the 2nd Brigade, the 1st Brigade returning to camp.

Refering to the artillery operations of the day, 100 rounds were fired by the 12-pr. Armstrongs, at a range of 2400 yards.

Many of the shells fell short in the first instance, and the elevation was subsequently increased.

The mortars had been delayed on the hill by a jam in the road (the 12-prs. being shifted from draught and mounted on elephants) and did not succeed in getting to a position from which their fire was very effective.

The Naval Brigade were out of range.

Return of ammunition expended on the 13th :—

	C. S.	D. S.	S. S.	E. T. F.	C. Percn.	10″ F.	15″ F.	Rocket.	Iron C.
G/14th R.A.	32	—	74	26	68	—	—	—	38
"A" Mortar Battery	94	15	—	—	—	105	17	10	—
"B" Mortar Battery	91	—	—	—	—	103	—	11	—
Detachment 5/25th R.A. two 8-in. mortars	11	—	—	—	—	—	—	—	—
Total	228	15	74	26	68	208	17	21	38

In the affair at Arogee on the 10th—

	C. S.	Shrapnel.	S. Case.	Rockets.
"A" Mortar Battery fired	55	55	2	15
	10″ F.	5″ F.		
	58	55		

whilst the Naval Brigade expended 23 rockets per tube, having 12 tubes.

The good effect of the shell fired from the steel guns on both occasions, admits of no doubt; the fuzes were excellent, burning with great regularity.

The wooden mortar bed introduced at Zulla was used at Magdala in firing double shell, and found incapable of standing a discharge with a larger charge than 3 oz.

Thus far good fortune had attended our steps and yet, had not the period during which it was necessary for us to remain in occupation of the camp below Magdala, before its final destruction on the 17th, been happily limited, we might, even then, have suffered a disaster; for already the scarcity of water, and bad provisions had increased our sick list, and, notwithstanding the few men wounded in the operations, our means of carriage was so small that our return march might have been accomplished with much difficulty, and our reaching the coast in time to embark before the rains set in, have been prevented.

On the 18th of April the Beshilo was re-crossed, and three days were spent on the Talanta Plain in re-organizing our Transport and Commissariat.

The following order was read to the troops assembled on a general parade, on the 21st April, 1868.

Adjutant-General's Office.

HEAD QUARTERS, CAMP TALANTA PLAIN,
20th April, 1868.

Soldiers and Sailors of the Army of Abyssinia.

The Queen and the people of England entrusted to you a very arduous and difficult expedition; to release our countrymen from a long and painful captivity, and to vindicate the honor of our country, which had been outraged by Theodore, King of Abyssinia.

I congratulate you, with all my heart, on the noble way in which you have fulfilled the commands of our Sovereign.

You have traversed, often under a tropical sun, or amidst storms of rain and sleet, four hundred miles of mountainous and rugged country.

You have crossed ranges of mountains, many steep and precipitous, more than ten thousand feet in altitude, where your supplies could not keep pace with you.

In four days you passed the formidable chasm of the Beshilo, and, when within reach of your enemy, though with scanty food, and some of you even for many hours without either food or water, you defeated the army of Theodore, which poured down upon you from its lofty fortress in full confidence of victory.

A host of many thousands have laid down their arms at your feet.

You have captured and destroyed upwards of thirty pieces of artillery, many of great weight and efficiency, with ample stores of ammunition.

You have stormed the almost inaccessible Fortress of Magdala, defended by Theodore and a desperate remnant of his chiefs and followers.

After you forced the entrance to his fortress, Theodore, who himself never showed mercy, distrusted the offer of it held out to him by me, and died by his own hand.

You have released not only the British captives, but those of other friendly nations.

You have unloosed the chains of more than ninety of the principal chiefs of Abyssinia.

Magdala, on which so many victims have been slaughtered, has been committed to the flames, and now remains only a scorched rock.

Our complete and rapid success is due, firstly, to the mercy of God, whose hand, I feel assured, has been over us in a just cause; secondly, to the high spirit with which you have been inspired.

Indian soldiers have forgotten the prejudices of race and creed to keep pace with their European comrades.

Never did an army enter on a war with more honorable feelings than yours. This it is that has carried you through so many fatigues and difficulties; your sole anxiety has been for the moment to arrive when you could close with your enemy.

The remembrance of your privations will pass away quickly; your gallant exploit will live in history.

The Queen and the people of England will appreciate and acknowledge your services; on my part, as your Commander, I thank you for your devotion to your duty, and the good discipline you have maintained throughout.

Not a single complaint has been made against a soldier, of fields injured, or villagers wilfully molested, either in person or property.

We must not, however, forget what we owe to our comrades who have been labouring for us in the sultry climate of Zulla, the Pass of Koomaylo, or in the monotony of the posts which maintained our communications. One and all would have given everything they possessed to be with us; they deserve our gratitude.

I shall watch over your safety to the moment of your re-embarkation, and shall to the end of my life remember with pride, that I have commanded you.

R. NAPIER, Lieutenant-General.
Commander-in-Chief,
Abyssinia.

The army started in three columns on the 21st, 22nd, and 23rd of April. These experienced some difficulty in the return march to Antalo, owing to the number of troops and followers in each, the exhausted state of the cattle, and the stormy weather they encountered, and some modification in their original formation was made. It would no doubt have been impolitic to reduce the size of the columns, so as to enable them to perform long and difficult marches with comparative ease, and too hurried a return would not have been sufficiently dignified; yet the re-assembly of the force at Antalo on the 12th of May without disaster was a relief to those who feared for our supplies, and dreaded the immediate downfall of the rains. It may, however, be as well to state that columns travelling through a mountainous country should be limited by the number of animals they require to accompany them, as well as the means of supply, the extent of camping grounds, and other of the usual considerations.

1000 mules are moved with ease, and do not impede the march of the troops; the columns returning from Talanta had each as many as 2500 baggage animals.

The difficulty of retaining the elephants in the 2nd Brigade, was found so great, that at Dildee a 4th column was formed with G/14th R.A., the 8-inch mortars, and 45th Regiment.

Once in Tigré we came upon the admirable roads constructed by the 2nd Division during our advance, and single file marching was at an end.

The casualties amongst the European troops since the commencement of the operations at this time, only amounted to 27; 5 officers and 22 men; 2 officers died violent deaths—out of a total of 520 officers and 4250 men landed in Abyssinia, and the expedition had lasted six months.

The following congratulatory message from H. M. the Queen was published at Antalo:—

Adjutant-General's Office.

HEAD QUARTERS, CAMP ANTALO,
12th May, 1868.

The Commander-in-Chief has the highest satisfaction in conveying to the army of Abyssinia the following message received this day by telegraph.

Sir Robert Napier most heartily congratulates all under his command on this flattering recognition of their services by Her Most Gracious Majesty Queen Victoria.

"The Queen sends hearty congratulations and thanks to Sir Robert Napier and his gallant force on their brilliant success."

By order of His Excellency the Commander-in-Chief,
FRED. THESIGER, Colonel,
Deputy Adjutant-General.

Here the plan of the embarkation of the troops originally drawn up when the head-quarters of the army were at a distance of 300 miles from the coast, was finally determined upon as we came to our most advanced telegraph station. The success which attended the exertions of all concerned in the movement of the garrisons of Antalo, Addigerat, and Senafé, and the five columns now formed of the troops of the 1st Division, must excite wonder, when it is remembered that twice during the progress of the troops a mountain torrent poured through the Pass of Sooro, and that everything tempted them to hurry the arrangements to a dangerous extent; yet nothing was relinquished along the road to mark our haste in leaving the country, and Kassa the Prince of Tigré was received and entertained at Senafé. On the 31st May the last of our troops were at Koomaylo, and with the exception of one small brigade, the army had already been embarked. The regularity with which the embarkation was carried out during the terrific heat encountered at Zulla in June, the order of the ships, their equipment, in fact the general management of this, not the least difficult portion of the undertaking, will add much to its success as a military enterprise. To Major-Gen. Russell, Captain Tryon, the Naval Transport agent, and Major Roberts, VC. Assist.-Qr.-Mr. General—those who so eagerly quitted Annesley Bay, must feel grateful for the exertions which produced so happy a result.

The labour of the embarkation may be estimated by reference to the following return, though a very large number of the followers had been returned to India during the months of February, March, and April, and the casualties amongst the natives between Zulla and Senafé were considerable.

	Officers.	Euro. Troops	Native Troops	Followers.	Civilians	Horses	Elephants.
Total number of Troops and followers in Abyssinia on the 1st of May, 1868.........................	501	3972	8976	20295	330	2538	40
Total number of Troops and followers who where despatched from Abyssinia between 21st Jan. and 30th April, 1868.	19	278	471	5919	109	—	—
Total number of Troops and followers landed in Abyssinia (deaths excepted)......................	520	4250	9447	26214	439	2538	40

Attributing our success in the first place to the overruling of Divine Providence, we cannot fail to recognise the wisdom which has so unhesitatingly supported the liberal measures of the Commander-in-Chief, and has reposed such implicit confidence in him, and must acknowledge that much is due to the unsparing hand with which the wants of an army operating at so great a distance from our shores have been supplied. In reviewing this slight sketch of our operations, I would direct attention to the different points in which we may hope that valuable experience has been gained.

Our condensers have enabled us to excite the wonder of savages, as a people who drink the sea, while Bastier's and Norton's pumps have made us comparatively independent in the matter of water on the line of march.

We have at least the knowledge which should lead to the organization and maintenance of an efficient transport and commissariat service, and possibly to the substitution of regimental supervision for that now adopted in both of these departments. We have secured to the service a pack saddle that admits of but little improvement, while what is more important, we have learned to move an army during a month's march without either baggage or followers, and have gained the certainty that the requirements of British troops in the field are so small as to make them capable of performing long marches with rapidity. The reduction of camp equipage, and the packing of stores, forage, &c. in small compass for mule carriage is not unimportant. If our carriage for sick has been unwieldy and cumbersome, we may congratulate ourselves that it has been so little used, and hope for improvement.

We have for the first time laid down a regular telegraph on field service, and have done so with success, and our system of signalling has been useful.

The accompanying reports on the employment of elephants for the carriage of field guns, and 8-inch mortars, and on the equipment of our mountain batteries, will prove how valuable has been the experience we have gained in the selection of the *matériel* of artillery for mountain campaigns.

While our steel guns have more than answered the expectations formed of them, the Snider rifle has been thoroughly tested as a weapon for rough service and good shooting.

The Abyssinian expedition bears strongly on the employment of native troops in our colonial dependencies, a question now under discussion.

Our troops have been engaged in the construction of a railway and of roads, which bear testimony to the superior skill of our Engineer Officers, and throughout the expedition the army has been independent of civilian engineers and mechanics.

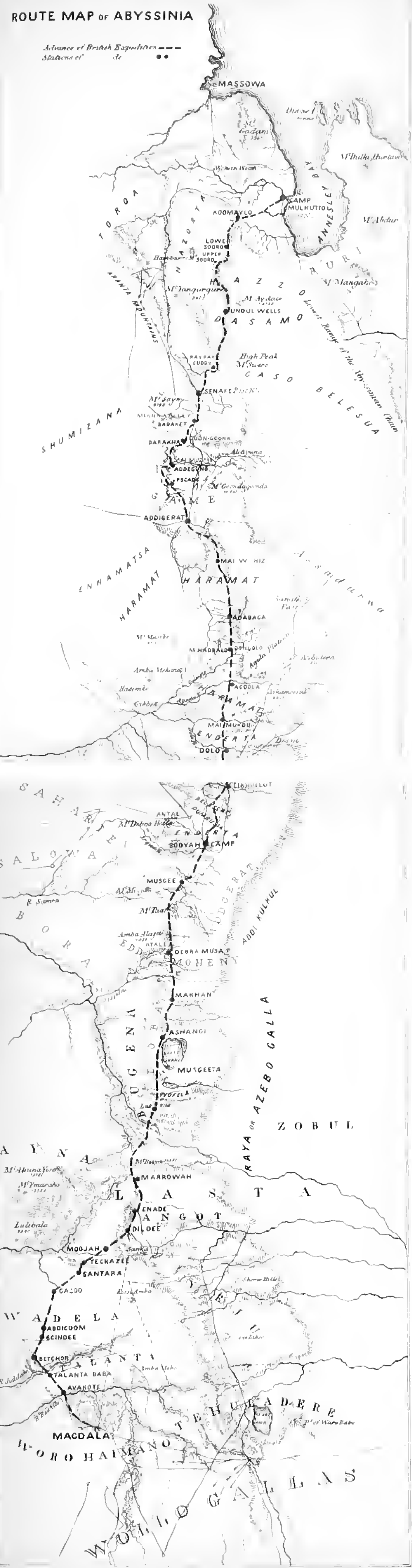
The sanitary measures adopted throughout have been effective.

Great opportunity has been afforded for a comparison of the different methods of equipping ships for troops in the ports of England and the three Presidencies; the comfort and convenience of the hospital ships have excited admiration.

The reports of Mr Blandford of the Geological Survey of India, and of Mr Markham, Secretary to the Royal Geographical Society, who travelled with the Force will interest those who care to follow the scientific researches prosecuted in a country bearing the marks of ancient civilization, which are met with in Abyssinia.

It is a subject for congratulation that the army was accompanied by Foreign Officers, representing the armies of France, Prussia, Austria, Italy, Spain, and Holland, whose accounts must necessarily contain a disinterested statement of the operations which have resulted in a speedy and successful termination of the Abyssinian Expedition.

Note to Map. In consequence of the difficult nature of the road between Marrowah and Dildee (18 miles), some of the troops were halted at Enade about four miles short of that place.



Lithographed at the Royal Artillery Institution

APPENDIX.

G. O. C. C.

HEAD QUARTERS, ZULLA,
23rd January, 1868.

Camp Equipage.

One bell tent for each Commanding Officer.
One do. for every two Officers to Senafé, and for three beyond.
One do. (single cloth) for every five Staff Serjts. or Warrant Officers.
One do. (single cloth) for every four Native Commissioned Officers.
One do. (single cloth) for every twelve European non-commissioned rank and file.
One do. (single cloth) for every fourteen Native non-commissioned rank and file.
One do. (single cloth) for Guards for each Regt. or Battery.
One do. (single cloth) for stores for each Regt.
One bell tent (single cloth) for Hospital for each Regiment.
One do. (single cloth) for Hospital Necessary for each Regiment.
Two tents (Native soldiers double-poled) for Hospital for each Regiment.
One tent (Native soldiers double-poled) for Hospital for each Battery.
One bell tent for Hospital for a Company of R.E.
One do. for Hospital for a Company of Native Sappers (when detached).
One do. for Hospital for a Battery of Native Artillery.

Carriage.

One mule for every two bell tents.
Three do. for every two Native soldiers double-poled tents.
One do. for conveyance of each Officer's personal baggage.
One do. for Mess Kit of every three Officers.
One do. for baggage of every three Staff Serjts.
One do. for baggage of every four European non-commissioned rank and file.
One do. for baggage of every three Native Commissioned Officers.
One do. for baggage of every five Native non-commissioned rank and file.
Five do. for Cooking Utensils of a British Regt.
One do. for Cooking Utensils of a Battery of Royal Artillery.
Two do. for Q.-M. Stores of a British Regiment.
One mule for Q.-M. Stores of a Native Regiment.
One do. for Office Books of each Battery.
One do. for Armourer's Stores of each Regt.
Eight do. for Entrenching Tools of each Regt.
Thirteen do. for Hospital Stores of each British Regiment.
Six do. for Hospital Stores of each Native Regt.
Three do. for Hospital Stores of each Batt. R.A.
One do. for Hospital Stores for each Native Battery or Co. of Sappers.
Two do. for Hospital Stores of a Company R.E.
Twenty-two do. for spare ammunition of a British Regiment.
Twenty do. for spare ammunition of a Native Regiment.
Six do. for spare ammunition of a Co. of R.E. or Sappers.

Sick Carriage.

Dandies (with four bearers each) will be issued at the rate of one for every twenty European non-commissioned rank and file, and one for every 100 native non-commissioned rank and file.

One doolie (with six bearers) will be allowed to each regiment.

Followers.

The only native followers, public or private, allowed to proceed with the troops will be as follows, and the extra carriage will be permitted for the conveyance of their baggage:—

Twenty-six cooks for each British Regiment.
Six do. for a Field Battery R.A.
Five do. for a Mountain Battery.
Three do. for a Company of R.E.
Puckal Bhesties according to existing Regulations.
Hand Bhesties according to existing Regulations.
One servant for Mess Kit of every three Officers.
One grasscutter for each Officer's horse.
One Syce or grasscutter for each battery horse of a Field Battery.
Twenty-five muleteers for each Mountain Battery R.A.
One grasscutter for every two mules of a Mountain Battery R.A. or Native Artillery.
Three artificers for each Battery of R.A., seventeen for Native Artillery.
Regimental and Battery Officers are allowed each a soldier servant.

In addition to the above, on the 3rd of February a proportionate allowance was granted for Staff Officers, their Clerks and Offices.

On the 14th February the Hospital Establishment suffered some reduction, and on the 23rd February the following order was published:—

Adjutant-General's Office.

HEAD QUARTERS, CAMP ADABAGAH,
23rd February, 1868.

Camp Equipage.

One bell tent (double cloth) for every three Officers (two senior Officers of a Regt. one between them).
Four bell tents (double cloth) for Hospital of European Regiment.
Two do. (double cloth) for Hospital of Native Infantry or Cavalry Regiment.
One do. (double cloth) for Hospital of each Battery of R.A.
One do. (single cloth) for ten Staff Serjeants or Warrant Officers.
One do. (single cloth) for eight Native Officers.
One do. (single cloth) for fourteen non-commissioned rank and file.
One do. (single cloth) for eighteen Native non-commissioned rank and file.
One do. (single cloth) for Guards of each Regt.
One do. (single cloth) for Stores of each Regt.
One do. (single cloth) for Hospital Establishment of each Battery or Regiment.
One do. (single cloth) for office purposes of every five clerks.

Carriage.

One mule for every two bell tents (single cloth).
Two do. for every three bell tents (double cloth).
75 lbs. weight for each Officer's personal baggage.
30 lbs. do. for baggage of every Warrant and Native Officer.
25 lbs. do. for baggage of every Staff Serjt. or non-commissioned rank and file.
75 lbs. weight for cooking utensils of Co. of European Infantry or Battery R.A.
150 lbs. do. Q.-M. Stores of a Regiment of Infantry (European).
75 lbs. do. for Regiment of Native Infantry or Cavalry, or Native Battery.
159 lbs. do. for Armourer's Stores of each Regt. of Infantry or Cavalry.
150 lbs. do. for Mess Kit of Six Officers.

Entrenching tools, hospital stores, Staff Officer's offices, and spare ammunition according to actual weight to be specially sanctioned.

Sick Carriage.

One doolie, with six bearers, for every 100 non-commissioned rank and file, European or Native.
Two mules with pads for every 100 non-commissioned rank and file, European.
One mule with pads for every 100 non-commissioned rank and file, Native.

Followers.

No private followers are to be allowed, except grasscutters for mounted Officers, and the only public followers for whom rations can be drawn are the following:—

Two cooks for each Company of Infantry or each Battery R.A.
Bhesties according to existing regulation.
Hospital Establishment do.
Artificers, Troop Moochees, Regimental Saddlers, &c. according to actual requirements specially sanctioned.
25 Muleteers for each Mountain Battery R.A.
1 Tent Lascar for every General Officer or A.-Q.-M.-General.

No syces to any Regiment of Cavalry or Battery of Artillery.
No Officers to be allowed any private carriage whatever.
Every Staff, Battery, or Regimental Officer is allowed a soldier servant.
No civilian clerks are to be permitted to accompany the force.

Scale of Rations.

Adjutant-General's Office.

HEAD QUARTERS, CAMP AGULA,
27th February.

European Troops.	oz.	Native Troops.	oz.	Followers.	oz.
Flour	16	Flour	14	Flour	12
Meat	24	Ghee	2	Ghee	2
Salt	$\frac{2}{3}$	Salt	$\frac{2}{3}$	Salt	$\frac{2}{3}$
Ghee	2	Meat	16	Meat	16
Vegetables	2	Kokum	$\frac{1}{2}$		

Return of Ordnance captured by the force under Sir R. Napier, G.C.S.I., K.C.B., in the Magdala Fortress on the 13th April, 1868, with a description of guns, howitzers, and mortars.

CAMP NEAR MAGDALA,
13th April, 1868.

1 bronze gun, length, 7 ft. 2 in., cal. 6″, native: mounted on Falla at the salient on a heavy field carriage with limber. This gun was found burst.

1 bronze gun, length, 7 ft. 2 in., cal. 6$\frac{5}{8}$″; at N.W. angle of Falla, carriage and limber similar to former, supplied with stone shot and heavy shot of lead and antimony; also one cylindro-conoidal stone shot, and chain shot. Found loaded.

1 do. do. Found on the King's road to Magdala, limbered up, a quarter of a mile towards Magdala.

1 bronze gun, length, 2 ft. 6 in., cal. 3″; native. Found on the ascent to Magdala
3 bronze howitzers, length, 2 ft. 10 in., cal. $2\frac{7}{8}''$. do
1 iron gun (native), 1-pr.; length 2 ft. $6\frac{1}{2}$ in., cal. 2″. do
1 bronze gun, length 2 ft. 10 in., cal. 5″; native. do
1 bronze howitzer, 2 ft. 11 in., cal. $4\frac{5}{8}''$; Turkish. do
3 bronze guns, 6-prs., length, 4 ft. 10 in., cal. $3\frac{5}{8}''$; Turkish. do
1 bronze gun, 18-pr.. length, 7 ft., cal. 5·1″; native. In the park facing Magdala.
1 bronze howitzer, length 2 ft. 5 in., cal. $3\frac{3}{8}''$; French. In the park facing Magdala. Cast at Toulouse 1822, named "Le Moinran."
1 bronze gun, length, 4 ft. 10 in., cal. $3\frac{7}{8}''$; Turkish. In the park facing Magdala.
1 bronze howitzer, length, 4 ft. 11 in., cal. $2\frac{7}{8}''$; native. do
2 bronze guns, length, 1 ft, 10 in.; native. do
4 bronze guns, 6-prs.; one French, one Turkish, two English. Cast at Cossipore, presented to King of Shoa during Major Harris' mission.
1 bronze howitzer, cal. $3\frac{7}{8}''$; native. In the park facing Magdala.
3 iron guns, length, 2 ft. $6\frac{1}{2}$ in., cal. 2″; native. do
1 bronze howitzer, cal. $4\frac{5}{8}''$; native. do
1 bronze mortar, 20-inch; thickness at muzzle, 8 in., chamber, 10 in. by 4, exterior length, 4 ft. 5 in.; cast at Gondar. At the extreme right of Islamgee mounted on a platform wagon; this had not been fired.
1 do 13-inch.; thickness at muzzle, $3\frac{5}{8}''$, chamber, 9 in. On platform wagon on lower road under Magdala; a first-rate casting.
1 do 10-inch; thickness at muzzle, $2\frac{1}{2}$ in., chamber, 6 in. Found with a platform wagon between Falla and Magdala, but thrown off the wagon, which was upset; the mortar was spiked, the spike having an eye could be easily withdrawn.
2 do (native) length, 4 ft. 10 in. Found in park, bearing inscription in native characters.
1 do 10-inch; length, 19 in. Found in park.
1 do $4\frac{3}{8}''$. do
1 do 6-in. do
1 do $2\frac{7}{8}''$. do

Summary:—Bronze guns, 24; iron guns, 4; brass mortars, 9. Total, 37.

With one exception the native ordnance was cast at Gaffat. The castings of the larger natures were inferior, with the exception of one 13-inch mortar. Stone shot were provided for all but the smaller guns, also mixed metal shot, but no shell of any description had been cast; stone shot, however, had been manufactured for all the mortars.

The powder of large grain without glaze appeared good, the charges were made up in bags of cotton cloth.

The guns were fired with priming and slow match.

Priming irons and implements of English manufacture were found in the park. Carriage and platform wagons of rough make, limbers, &c. indicating that the German pattern had been followed; they had, however, stood the journey from Debra Tabor.

The mortar beds of wood were remarkably good.

To be continued in the next Number.

p. 182, lines 14, 15, 21, *for* Mortar Battery, *read* Mountain Battery.

NOTES ON ELEPHANT CARRIAGE AND STEEL MOUNTAIN BATTERIES EMPLOYED IN ABYSSINIA.

Elephant carriage for field guns and mortars.

[COMMUNICATED BY LIEUTENANT CHAPMAN, R.H.A.]

The following extract from the report of Lieut.-Colonel Wallace, R.A., on the carriage of 12-pr. guns and 8-inch mortars upon elephants is forwarded by permission.

"The four guns and carriages of G/14th R.A. (12-pr. B.L. Armstrong guns) were distributed in the following manner :—

For each gun	1	elephant ...	4
〃 carriage..............................	1	〃 ...	4
〃 limber and 1 wheel	1	〃 ...	4
〃 pair of ammunition boxes & 1 wheel	1	〃 ...	4
Every 3 wheels of remaining 8	1	〃 ...	3
		Total	19

one of the last elephants having but two wheels, the load was made up by the shears, tackle, &c.

"There are no means of weighing the several portions of the carriages, *matériel* &c., but the following weights were given me at the Poona Arsenal. I am inclined, however, to believe that the carriage is considerably heavier than noted.

Gun, 8 cwt. 1 qr., or 924 lbs; carriage, 8 cwt. 2 qrs. 14 lbs., or 966 lbs. limber, 4 cwt. 2 lbs., or 450 lbs.; one wheel, 2 cwt. 3 qrs. 6 lbs., or 314 lbs.; ammunition box, 2 cwt. 1 qr. 3 lbs., or 255 lbs.

"The cradle probably weighed about 150 lbs., the elephant pads, guddeelah, &c. are supposed to weigh about 500 lbs. each set.

"Consequently, the weights of the several loads are as follows, viz.—

		lbs.	
For gun elephant	gun	924	1574 lbs.
〃	cradle	150	
〃	pad, &c. ...	500	
For carriage elephant	carriage ...	966	1616 lbs.
〃 〃	cradle ...	150	
〃 〃	pad, &c. ...	500	
Load of ammunition boxes	2 boxes......	510	1324 lbs.
〃 〃	1 wheel......	314	
〃 〃	pad, &c. ...	500	
Load of wheels	3 wheels ...	942	1442 lbs.
〃	pad, &c. ...	500	

Loading.

"With respect to the loading, it has been found impracticable to use the shears, it being difficult to get the animals to remain quiet under the fall; moreover, the nature of the soil is seldom such as to afford a good hold for the pickets. The loading has, therefore, been effected as follows, in the case of the gun, one skid (with the carriage two skids) is placed, with one end resting on the ground, the other on the cradle, the elephant being of course in a sitting posture. The breech-screw being removed,* handspikes are inserted in the bore at breech and muzzle, and the gun is lifted up along the spar by eight men to its rest in the cradle.

"To assist the lift, a drag-rope is attached to the gun at the trunnions, passed over the cradle and manned on the opposite side by 3 or 4 men, with this too, the gun is kept steady while the men who are lifting obtain a fresh purchase.

"The carriage being heavier, 12 men are required to lift it; the arrangements are the same, except that two skids are used instead of one, up which to slide the weight. The limber is lifted bodily up (no skidding being used) and placed in its cradle, a wheel is then placed on the top and lashed securely.

"The ammunition boxes are carried slung, one on each side of the animal, with a wheel laid on the top of the pad and lashed.

"The three wheels are slung, one on each side, and one laid on the top.

"With regard to the time occupied in loading, the chief delay takes place in equipping the elephants with their gear and cradles; once this is done, the gun and carriage are loaded in 2 or 3 minutes; the other loads take longer on account of the lashing.

Carriage for 8-inch mortar.

The 8-inch mortar, with its bed, requires two elephants, the weights being as follows, (those of travelling bed, cradle, pad, &c. being given approximately only) :—

Light 8-in. mortar, 8 cwt. 1 qr. 12 lbs.; iron (firing) bed, 7 cwt. 2 qrs. 6 lbs.; wood (travelling) bed, 1 cwt. 2 qrs.; cradle, 2 cwt. 1 qr.

"The load would then be,

For mortar elephants :—mortar, 924 lbs.; travelling bed, 168 lbs; cradle, 252 lbs.; pad, &c. 500 lbs.; total, 1844 lbs.

For bed elephants :—iron bed, 840 lbs.; travelling do. for do., 168 lbs.; cradle, 252 lbs.; pad, &c. 500 lbs.; total, 1760 lbs.

"The weights of skids, implement boxes, handspikes, &c. are not known, but they form a good load for an elephant.

"The powder has been carried on another elephant, and the shells on mules, (4 per mule), the powder could likewise have been so carried.

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* Breech-loading guns are much more easily employed on this service than are muzzle-loaders, owing to the facility afforded for the employment of handspikes to lift the guns into their cradles in place of parbuckling as formerly.—E. C.

"The loading has been thus effected—

"The elephants being seated, two parallel skids are placed with their upper ends resting on the cradle, their lower ends being on the ground; their parallelism is preserved at the proper distance by iron stays; they are formed with a track, along which the iron trucks of the travelling bed, fitted with iron flanges, run. Tackle is attached to the travelling bed, passed over rollers which are fixed in the cradle and manned on the opposite side of the animal; four men with handspikes heave the mortar or bed up to the skid and, the tackle being hauled on, the load is run up rapidly into its cradle.

"To prevent the pad being displaced while the load is hauled up, a third skid (somewhat shorter) is placed on the off (hauling) side, with one end resting against the cradle, thus checking the tendency of the cradle to come over with the haul and supporting the gear.

"The delay in preparing the elephant is the same as with the gun.

Unloading.

"Unloading is performed under the same arrangements with both descriptions of ordnance; with the guns it is a much easier process than that of loading, and frequently only one skid has been employed in unloading the carriage.

Equipment.

"For marching in an ordinary country, the equipment now used is, I think, almost all that can be desired; the only alteration I would suggest, is that curled hair should be used, as for saddles, instead of coir (cocoa nut fibre) for the stuffing of the under pad, which should be somewhat thicker than that now used.

"The skin of the elephant is so singularly tender that it easily becomes chafed, and serious galls and sores ensue from friction as well as from the pressure of the heavy weights carried, which have remained on the elephants' backs, at times, from 12 to 20 hours without interruption.

"In a mountainous country, such as that recently travelled over, I would propose that the pads be fitted with breechings and breast-pieces, as the rope now used, which in the one case is pulled tight under the tail, and in the other under the throat, has caused very severe galls and sores to those parts, notwithstanding that a piece of chafing-leather was placed between the rope and skin; moreover, in ascending, the strain, caused by the weight being thrown back, acted very detrimentally on the respiration, almost choking the elephant; to remedy this defect, probably an arrangement like a horse collar might be used; I consider it would also be an improvement if the pads were attached and secured in the same manner as the cradles, that is, by being secured from the sides under the belly instead of by a rope passing completely round and over the animal; the objection to the present arrangement is, that if the ropes are found to be loose, either from carelessness on the part of the mahout, or the tricks of the animal, they cannot be adjusted without removing the loads; whereas, under the arrangement proposed, the ropes can be drawn tight as the girths of a saddle.

"The cradles, &c. supplied to G/14th R.A. are somewhat slight, having been intended for use with a 6-pr. Battery. The beds for the guns were cut to receive the larger circumference of the 12-prs.

NOTES ON THE EQUIPMENT, &c. OF THE STEEL MOUNTAIN BATTERIES EMPLOYED IN ABYSSINIA.

BY LIEUTENANT CHAPMAN, R.H.A.

Shortly after the equipment of the Steel Mountain Batteries was despatched from England, an account appeared detailing the establishment, &c. proposed for the above batteries;* the following notes will show what alterations were made in the original proposal, during the expedition.

One armourer-serjeant and four n. c. officers were sent out from England with the guns and equipment of each battery; an assistant-wheeler and a shoeing-smith for each battery were brought out by Lieut.-Col. Milward, R.A.

The batteries were manned by the following garrison batteries of the 21st Brigade from Bombay.

No. 3/21st R.A., under Lieut.-Col. Penn ("A" Battery).
" 5/21st R.A., " Captain G. Twiss ("B" Battery).

Lieut.-Col. Penn and Captain Twiss reached Zulla on the 1st January, and took over the equipments and mules of their batteries, during the first week in January. Three weeks were occupied in drill and practice before the batteries were sent forward.

"A" Battery left Zulla on the 28th January, "B" Battery being detained until the 28th February; the mules of this battery were employed on convoy duty during the last five weeks of their stay at Zulla.

Detail of Mules with each Battery.

Mules.	No. 1 subdivision	Mules.	No. 2 subdivision	Mules.	No. 3 subdivision	Mules.	No. 4 subdivision	Mules.	No. 5 subdivision	Mules.	No. 6 subdivision
1	Gun	1	Gun	1	Gun	1	Gun	1	Gun	1	Gun
1	Carriage	1	Carriage	1	Carriage	1	Carriage	1	Carriage	1	Carriage
1	Wheels ...	1	Wheels ...	1	Wheels ...	1	Wheels ...	1	Wheels ...	1	Wheels
1	1st amm.	1	1st amm.	1	1st amm.	1	1st amm.	1	1st amm.	1	1st amm.
1	2nd do. ...	1	2nd do. ...	1	2nd do. ...	1	2nd do. ...	1	2nd do. ...	1	2nd do.
1	3rd do. ...	1	3rd do. ...	1	3rd do. ...	1	3rd do. ...	1	3rd do. ...	1	3rd do.
1	4th do. ...	1	4th do. ...	1	4th do. ...	1	4th do. ...	1	4th do. ...	1	4th do.
1	Dble. shell	1	Dble. shell	1	Dble. shell	1	Dble. shell	1	Dble. shell	1	Dble. shell
1	Rockets...	1	Rockets...	1	Rockets...	1	Rockets...	1	Rockets...	1	Rockets
1	Mis. stores	1	Sp. wheels	1	Sp. carr....	1	Sp. cradle	1	Sp. wheels	1	Forge
10	—	10	—	10	—	10	—	10	—	10	—

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* Vide Vol. V. p. 452.

Mules for 1*st Reserve, carried with the Battery.*

15	for	double shell	120 double shell.
5	"	rockets	80 rockets.
2	"	shrapnel	32 shrapnel.
1	"	case	20 case.
1	"	powder.	
1	"	fuzes.	
5	"	*matériel*	Vet. stores, shoes and nails, iron, wood, charcoal, leather, &c. &c.
1	"	wheeler's tools	in addition to those originally supplied with equipment.
31			

Ponies		
1	for	serjeant-major,
1	"	qr.-mr.-serjeant,
1	"	armourer serjeant,
1	"	conductor of stores,
1	"	trumpeter.
5		

Otago saddles	100
Riding do.	5

Summary.	Mules
Battery	60
1st Reserve	31
Spare	19
	110
Ponies	5

Extract from Battery Orders.

"B" Mountain Battery,
Zulla, 19th July, 1868.

"The mules and saddles for the reserve will be furnished in equal proportions by the several subdivisions.

"Reserve loads will be packed separately, and the mules picketed with their subdivisions.

"The reserve is under the charge of the Conductor of Stores."

Four spare wheels were carried with each half-battery in Nos. 2 and 5 subdivisions.

The great strain upon the wheels in firing made the large proportion of spare wheels carried with the batteries necessary.

The spare wheel load assumed the shape of an inverted V, and with "B" Battery the shafts of the three subdivisions were carried with this load between the wheels instead of with the gun, in order to render that load as free as possible for mounting and dismounting.

The wooden cradles were early dispensed with for gun and carriage, but retained for the carriage of the wheels on third mule, as being more convenient.

The load comprising wheels and carriage, as originally laid down, being considered too heavy, the old plan of carrying the wheels separately was reverted to.

The iron cradles (in separate pieces) are easily fitted to any Otago saddle, and answer every purpose, though the arms are adjusted with difficulty, and are too weak in the joints.

It was found that the carriage will ride on an Otago saddle without any cradle at all.

The forge-load at first appeared badly adjusted, the bellows on one side weighing down the anvil block and hammer on the other, though the weights of each approximate 98½ lbs.

With equal weights the principle to be observed with all loads is that a straight line passing through the centres of gravity of the packs on either side should be horizontal.

By adding links to the chains supporting the block and anvil, the forge load has been made to ride well.

Two iron supports fitted by means of screws and nuts, were proposed by Col. Wray, C.B., to enable the iron cradle to carry the gun lengthwise instead of athwart.

They were brought out with the battery; the question, however, of changing the position of the gun has never been raised, the extreme length of the gun (29 inches) being so small that no alteration is required; the present method of carrying it is the most convenient for mounting and dismounting, and the gun lies near the mule's back, though safely raised above it.

A mortar-bed designed by Lieut. Curtis was made for each subdivision and carried on the double shell load of the first line.

2 cheeks, teak, 2½″ thick, 23″ base, 11½″ deep from trunnion holes.
1 rear transom, 5″ × 3″ teak }
2 front do. 2½″ × 2″...... } weight, 75 lbs.
2 ⅝ iron bolts with nuts ...... }
4 ⅝ eye bolts, securing capsquares and passing right through the cheeks.

Two bars of wood two inches square passed through iron staples fitted into the cheeks at the base prevent the upsetting of the bed on the discharge of the piece; these are four feet long, and enable the gun and bed to be carried by either two or four men.

This bed will not retain its position when a larger charge than 3 oz. is used, but it would seem advisable to construct a light bed for double shell firing, or even to supersede the wheel carriage altogether. Lieut. Nolan designed a sliding tangent sight for use with the above.

The boxes containing "miscellaneous stores" and the small store boxes, carried with the gun being too tightly packed for convenience, small wooden boxes with sliding tops were fitted to the wooden cradle carried by the wheel mule, leaving the contents of the several boxes as under :—

Miscellaneous Store Boxes.

Armourer-serjeant's tools,
Wheeler's do.
Collar-maker's do.
1 set of entrenching tools on the top of saddle completing the load.

Box on Wheel Mule.

4 sets, shoes and nails,
1 spare lanyard,
1 set, bits for borer,
1 measuring cup, copper,
1 spare linchpin and washer,
1 hold-all, containing fuze-extractor, spike, turnscrew, &c.

In addition to the above the following spare stores were carried by the subdivisions undermentioned :—

No. 1, spare tube-pocket and lanyard,
No. 3, spare skein, Hambro' line,
No. 4, spare arms for cradle,
No. 5, measuring line for 50 yards,*
No. 6, spare tube-pocket and lanyard,
A small oil-can was fitted for each box.

On the spare cradle carried in No. 4 subdivision a similar box is placed, containing,—

Quadrant, spirit-level, funnel, two gauges.

Store boxes with Gun.

Near box:—1 tube-pocket with 50 tubes, straps for do. detached, 1 lanyard, 50 tubes in case.

Off box:—Tangent sight, 1 set bits, 2 hand-borers, 2 shell keys, 1 screw-wrench for fore sights.

In addition, a set of entrenching tools,—

1 axe, felling, 1 do. pick, 1 shovel, 1 bill-hook, 1 reaping-hook, weighing, with the board to which they are attached, about 28 lbs., are carried with each subdivision on the fourth ammunition mule.

Two similar sets of entrenching tools, and four sets with pickaxe, shovel, bill-hook, and reaping-hook are carried on six of the double-shell loads of the reserve.

The present system of draught is faulty: though on more than one occasion the guns were dismounted and put in draught, this could not be done in travelling down hill, and it becomes a question, whether if the loads are lightened, as they have been for this expedition, the guns would ever be placed in draught in a mountainous country; this bears on the question of superseding wheel-carriages by mortar-beds, when heavy projectiles are fired from very light pieces in *mountain* artillery.

Old oars procured from the navy were cut up, the wood being carried to replace the shafts in case of injury.

The Otago saddles supplied for the battery were excellent.

Sixty additional ones were obtained from the Land Transport Corps to complete the equipment. The stuffing of the pads with these, as with all those first received by the land transport, had not been properly tested, the cause of many mules being disabled during the expedition by sores on the ribs. Every opportunity was taken of greasing the saddles, &c. and of removing the hair from the pads, but with constant marching this was done with difficulty.

A full report on the pack-saddles employed with the force will be made by a committee assembled in Abyssinia for that purpose.

To lighten the ammunition loads carried on three mules of each subdivision, one common shell was removed from each box; to replace the above, sixteen common shell were carried upon a fourth ammunition mule in packing cases, making the number of rounds per subdivision 64.

Four rockets were removed from each of the panniers (leather) carried by the rocket mules, and 80 rockets were carried in the first reserve.

A reserve of 120 double shell was considered necessary to meet the possibility of a regular bombardment; the double shell were filled with No. 3 rifle powder procured from the navy.

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* This measuring line was used in measuring a base with a sliding rule, invented by Lieut. Nolan, for measuring distance, which proved very useful.

Detail of Loads.

Gun Mule.

	lbs.	oz.
1 Saddle, Otago,* with iron cradle, surcingle omitted 1 Web wantie	40	12
2 Boxes, small store, Near	7	10
2 Boxes, small store, Off	6	2
1 Bearer or splinter bar, Near	3	7
2 Sponge, Off	4	8
1 Ordnance steel	150	0
1 Cover, pack-saddle	6	8
1 Leather skin (with water)	7	10
	226	9

Carriage Mule.

	lbs.	oz.
1 Saddle, Otago with iron cradle* 1 Web wantie	40	12
1 Carriage complete	108	0
1 Box, tin (half-round), with 3 lbs. grease	3	8
1 Elevating screw	6	12
1 Rope, drag, or trace, single off	3	0
1 Cover, pack saddle	6	8
1 Leather skin (water)	7	10
	176	2

Wheel Mule.

	lbs.	oz.
1 Saddle, pack, mountain artillery, complete with arms, without wantie, but with one stirrup leather to secure wheels	65	0
2 Wheels with linchpins and washers	80	0
1 Store box	23	0
1 Cover, pack saddle	6	8
1 Leather skin (water)	7	10
	182	4

1st, 2nd, 3rd Ammunition Mules.

	lbs.	oz.
1 Saddle, Otago*	32	0
4 Ammunition boxes, 1 common shell filled; 2 shrapnel with primer; 2 case each	166	0
1 Ammunition box, 2 cartouches, canvas; 21 cartridges, 6 oz.; ten 5″ wood fuzes; ten 10″ wood fuzes; 2 boxes, tin, for fuzes	28	6
1 Cover, pack saddle	6	8
1 Leather skin (water)	7	10
	240	8

N.B. No. 1 ammunition mule carried twenty-two 6 oz. cartridges.

4th Ammunition Mule.

	lbs.	oz.
1 Saddle, Otago*	32	0
2 Boxes, packing, 8 common shell each	152	0
Entrenching tools	28	0
1 Leather bucket	3	10
1 Cover, pack saddle	6	8
1 Leather skin (water)	7	10
	229	12

Double Shell Mule.

	lbs.	oz.
1 Saddle, Otago*	32	0
2 Boxes D. S.:—4 double shell; five 15″ wood fuzes; 4 cartridges (3 oz.)	166	0
1 Mortar bed, with side bars	45	0
1 Cover, pack saddle	6	8
1 Leather skin (water)	7	10
	257	2

Rocket Mule.

	lbs.	oz.
1 Saddle, Otago*	32	0
2 Panniers, leather, 6 rockets on each	148	12
1 Rocket machine, 2 cases, leather	32	0
1 Wood small store box with friction tubes	7	8
N.B.—Nos. 2, 3, 4 and 5 do not carry machine or small store box.		
1 Cover, pack-saddle	6	8
1 Leather skin (water)	7	10
	234	6

Miscellaneous Store Mule.

	lbs.	oz.
1 Saddle, Otago*	32	0
2 Boxes, near and off	152	0
1 Set entrenching tools, with centre-board	40	0
1 Cover, pack saddle	6	8
1 Leather skin (water)	7	10
	238	2

Spare Wheel Mule.

	lbs.	oz.
1 Saddle, Otago, with loading straps, &c.	39	0
4 Wheels in canvas	160	0
3 Shafts	25	14
1 Cover, pack saddle	6	8
1 Leather skin (water)	7	10
	239	0

Spare Carriage Mule.

	lbs.	oz.
1 Saddle, pack, mountain artillery, without arms	63	0
1 Carriage	108	0
1 Grease box	3	8
1 Cover, pack saddle	6	8
1 Leather skin (water)	7	10
	188	10

Spare Cradle Mule.

	lbs.	oz.
1 Saddle, pack, mountain artillery, without arms	63	0
1 Small store box on cradle:—1 Quadrant in case; 1 spirit-level; 2 gauges; 6 wood tangent sights	20	12
1 Cover, pack saddle	6	8
1 Leather skin (water)	7	10
	97	14

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* Without stirrup leathers, stirrups, or loading straps.

Forge Mule.	lbs.	oz.
1 Saddle, Otago*	32	0
1 Bellows and hearth	98	8
1 Anvil; 1 block for anvil (35 lbs.); 1 hammer (7 lbs.)	98	0
1 Box, tools, poker, &c.	10	0
1 Cover, pack saddle	6	8
1 Skin (water)	7	10
	252	10

The following are the weights carried by mules of the 1st Reserve:—

	lbs.	oz.
6 Mules, double shell, each	229	2
9 〃 〃 〃 〃	203	2
2 〃 Rockets 〃	223	2
3 〃 〃 〃	245	2
2 〃 Shrapnel 〃 〃	205	2
1 Mule Case 〃	191	2
1 〃 Fuzes, &c.	185	1
1 〃 Powder	201	2

5 Mules carry material, the loads varying in weight, 1 mule carrying additional wheeler's tools.

1 Cloak……………… }
1 Blanket…………… } per man were carried by the mules of the battery.
1 Waterproof sheet }

The steel guns have more than answered the expectations formed of them. Some improvement may be made in the method of fitting the fore-sight; this is brittle, and being screwed in, is frequently broken off at the neck of the thick screw. A sight block might be turned as a portion of the gun.

The carriages seem capable of little improvement, but the wheels used with the batteries during the expedition were not strong enough.

Wheels of the Madras pattern were constructed and sent out to Abyssinia, but did not arrive in time to be used.

Of the projectiles, the *common* and *double shell* were very effective.

The shrapnel has little or no effect beyond 600 yards, though used with success at "Arogee" on the 10th April; it is quite certain that the present burster frequently fails to break up the case, and that the bullets themselves have but little penetration.

An improved shrapnel with a burster contained in a tin cylinder has, I understand, been made for 7-pr. rifled guns (M.L.), but none were received before the division was broken up.

The case shot is useless beyond 150 yards, and with a 6 oz. charge the case often remains entire.

The rockets have at all times made capital practice, though after an exposure of seven months the whole of the composition has in some cases gone off explosively, not however detracting from the range of the shell of the rocket, though rendering it comparatively useless. It seems a mistake to fire these projectiles with a high elevation, their range allowing the composition to be expended, in such a case, before they reach the object aimed at; they cannot however be fired with a smaller elevation than 5°.

The fuzes have at all times burned with great regularity. I am inclined to doubt the necessity of the 5″ fuze. Some attempt was made at "Ashangee" to discover whether they are extinguished on the shell striking the water; it was difficult, however, to submit them to an accurate test.

The ammunition boxes in size and form meet every requirement, but it is probable that "Clarkson's material" would be better fitted for rough work and exposure than cedar wood. The fittings of the double shell boxes are heavy. The same fault may be found with the rocket panniers; these projectiles were very well preserved in packing cases.

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* Without stirrup leathers, stirrups, or loading straps.

The packing cases of the reserve, and those in which the battery itself was packed were excellent; their size enabled them to be easily handled, and they have been very useful.

Mules.

The average height of the mules employed with the batteries was about 14 hands; some, however, of the best were very small indeed, procured either from Cyprus or Smyrna. Those from Italy and Valencia are chiefly of a dark-brown colour, while the Gibraltar mules are distinguished by the zebra mark clearly defined along the back and down the shoulders.

In selection, the chief points attended to have been—

> Breadth of chest, a full and arched back, large girth, good legs and feet, age about six.

Many that have been already saddled bear the marks in white patches on their backs.

A short mule about 13·1, possessing the good qualities above noted, seems well fitted for mountain artillery; the larger mules break down as soon as the supply of forage is reduced.

In comparing the loads put upon animals of this size with those ordinarily carried by pack mules, it must be remembered that the mules of the batteries were subject to hard marching on a short ration from the end of January to the end of May.

Ration at Zulla—8 lbs. beans; hay or chopped straw, 15 lbs.

The condition of those of "A" Battery at the conclusion of the expedition, and the small loss they had sustained were subjects of general remark.

The mules of "B" Battery had a larger share of convoy duty before leaving Zulla, and more incessant marching to get to the front, while a larger reduction had been made in the native establishment of this battery than in that of "A," so that greater difficulty occurred in procuring grass; hence they could not be compared with those of "A," but were in better condition than the animals of the Land Transport Corps, carrying loads of 150 lbs. only.

Mules giving much trouble in saddling were exchanged before we left Zulla; such should never be given to the artillery.

Two or more Maltese carts would be usefully employed with any mountain battery where the roads are tolerably good. All battery mules, of sufficient size, should be broken for draught.

The girthing of mules requires great care, heavy loads reducing the bulk of the pads and causing the girths to slacken. The girths of the Otago saddle were in general too long.

Establishment.

The Abyssinian Expedition may be considered an exceptional case, in the length of the march the army was called upon to make, and the very difficult nature of the country traversed. Though an unusually healthy climate did much to lighten the labours of the troops and prevent sickness, yet neither this good fortune, nor immunity from loss in actual fighting could be calculated on, and the whole of the artillery of the 1st Division ran great risk of becoming ineffective in being much below the requisite strength.

When officers and men are alike called upon to perform the fatiguing duties which fell to the share of the Royal Artillery during the expedition, the individual exertions of each are doubly valued. The danger to which the credit of the Regiment must be exposed on service, so long as our batteries are under-manned is apparent. Without attempting to fix the establishment required for a mountain battery on service, I would call attention to the fact, that it has been absolutely necessary to procure men from the infantry to lead the battery mules when the difficulties of the road required that every mule should be led separately.

Whilst the batteries were being organized at Zulla, a proportion of European drivers, volunteers from the 4th K. O. Regiment, were attached to the batteries for the expedition, receiving gunners' pay; these men did excellent service and, from the first, took up their new work with admirable spirit.

The European drivers attached were armed with the Snider carbine, with which also all the gunners of the battery were provided; this proved in no way inconvenient during the work of mounting and dismounting the guns or of working them in action.

A comparison of the establishment with which "B" Battery left Addigerat on the 8th of March with that of the Mountain Battery of 5/25th R.A. despatched from Bengal for service, will serve as a guide in deciding how many men, &c. are required for a battery of mountain guns. The establishment of "A" Battery on leaving Antalo, differed little from that of "B" except in the number of native muleteers (grasscutters), those of "A" battery being double those of "B" in number.

Establishment of "B" Battery 5/21*st R.A.*

March 8, 1868.

1 Captain,
4 Subalterns,
1 Assistant-surgeon,
2 Staff-Serjeants,
6 Serjeants (including 1 armourer serjeant, 1 conductor of stores,
68 rank and file, and artificers,
29 European drivers 4th K. O.
26 Muleteers (native),
6 Store Lascars,
2 Cooks,
4 Bhesties.

Hospital Establishment.

1 Bhestie,
1 Dhobi,
1 Wardboy,
1 Sweeper,
6 Dhoolie bearers,
9 Officers grasscutters.

23 men of 4th K. O. attached, were available for baggage guards, &c.

Baggage Animals.

	Mules
6 Officers baggage	3
" mess	1
Baggage of 130 European soldiers	22
" 38 natives	4
Tents	8
Hospital	3
Carriage for sick	3
Rations for immediate use	5
Cooking pots and stores	1
Snider ammunition	5
Meat	1
	56
Grain (3000 lbs.)	24
	80

Battery Establishment.

Officers' horses	9
Ponies	5
Mules	110

One muleteer was provided with every three baggage mules.

At Dildee the baggage animals were reduced to—

	Mules
Carrying rations for 15 days	35
Snider ammunition	5
Cooking pots	1
Carriage for Sick	3
Hospital	3
	47

Establishment of 5/25*th R.A.* (7-*pr.* "*B*" *Mountain Guns*).

Two captains, four subalterns, two assistant-surgeons, one apothecary, one steward.

Non-commissioned officers rank and file	137
Native drivers	193
Lascars	13
Native artificers	4
Public followers, grasscutters, bhesties, sweepers, &c.	123

	Mules
Battery	252
Officers baggage	13
	Horses
Battery	4
Officers	16

This battery doubtless landed with a full establishment, and the reduction of baggage ordered must have curtailed the above numbers had the battery proceeded to the front, yet the great advantage of a liberal establishment, and of a fixed scale of baggage animals under battery arrangements is worthy of attention.

N.B. Before 5/25th R.A. embarked at Calcutta, it was intended to furnish a detachment of 28 gunners for the mortars to be carried with the force, and this number of men had been added to the original strength.

Detail of Kit (*gunners*) 25 *lbs. per man.*

1 Suit Khakee,
2 Pair socks,
2 Towels,
2 Flannel shirts,
1 Comb and brush,
1 Sponge,
1 Cloth jacket,
1 Pair cloth trowsers,
1 Forage cap,
1 Pair long boots,
2 Cholera belts,
1 Serge tunic,
1 Black bag (between two men).

Carried on Battery mule.

1 Great coat,
1 Waterproof sheet,
1 Blanket,
1 Canteen.

In wear.

1 Pair Khakee trowsers,
1 Khakee coat,
1 Helmet,
1 Flannel shirt,
1 Pair socks,
1 Pair braces,
1 Bible and Prayer Book, } * between 4 men.
1 Cloth brush, }
1 Pair boots (cossacks),
1 Pair gaiters,
1 Cholera belt,
1 Knife, fork, and spoon, } *in havresack.
1 Pocket knife .... }
1 Soda water bottle,
1 Skin water (filled) } * between 4 men.
1 Saleetahs .... }

Range tables drawn up by Lieut. Nolan for practice with double shell.

Charge 3 oz.				Charge 2 oz.		
Range.	Elev.		T of flight.	Range.	Elev.	
yds.	°	′	″	yds.	°	′
100	1	26		100	2	0
200	2	50		200	4	17
300	4	46	2·2	300	7	20
400	7	12	3·1	400	10	42
500	9	42	4	500	14	0
600	12	14	4·9	600	17	20
700	14	50	5·9	700	21	13
800	17	40	6·3	800	27	0
900	20	33	7·6	820	34	0
1000	25	30	8·9			
1100	29	45	10			
1160	34	0	12			
1200	36	58	14			

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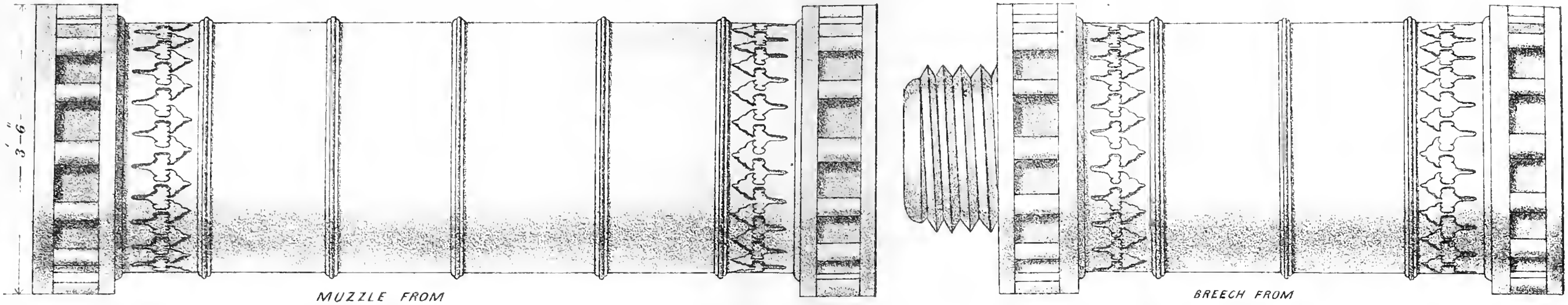
* These articles do not come under the head "in wear."

CANNON OF MUHAMMAD II, *cast A. H. 868 (A. D. 1464).*

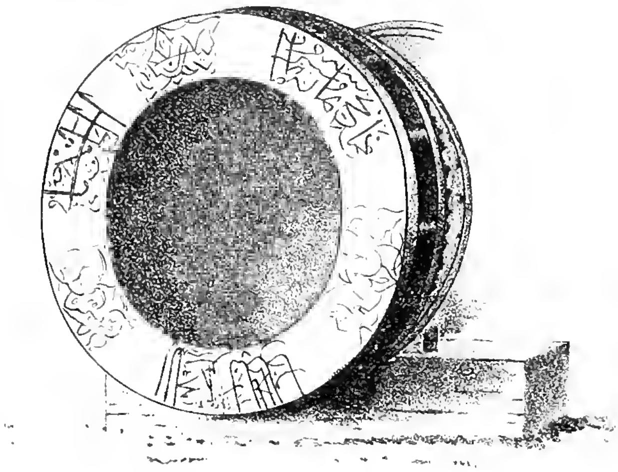
This great piece of ordnance formed part of the armament of the Castle of Asia at the mouth of the Dardanelles, and was presented to Her Majesty by the Sultan Abdul Aziz Khan, 1866. It is now in the MUSEUM OF ARTILLERY, WOOLWICH. Length, 17 feet; diameter of powder chamber, 10 inches; diameter of bore, 25 inches; weight, 18 tons 14 cwt. 3 qrs. The stone shot each weigh 670 lbs. nearly. An inscription near the vent states that the weight of shot is 240 okes = 679 lbs. powder due 17½ okes = 49·5 lbs. Degrees, 3.

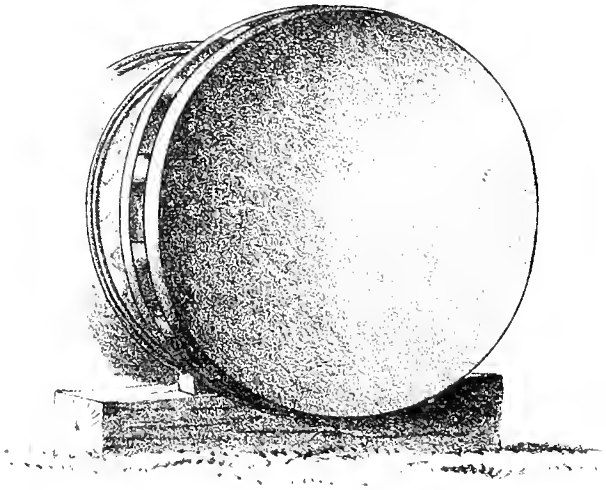


MUZZLE FROM PHOTOGRAPH

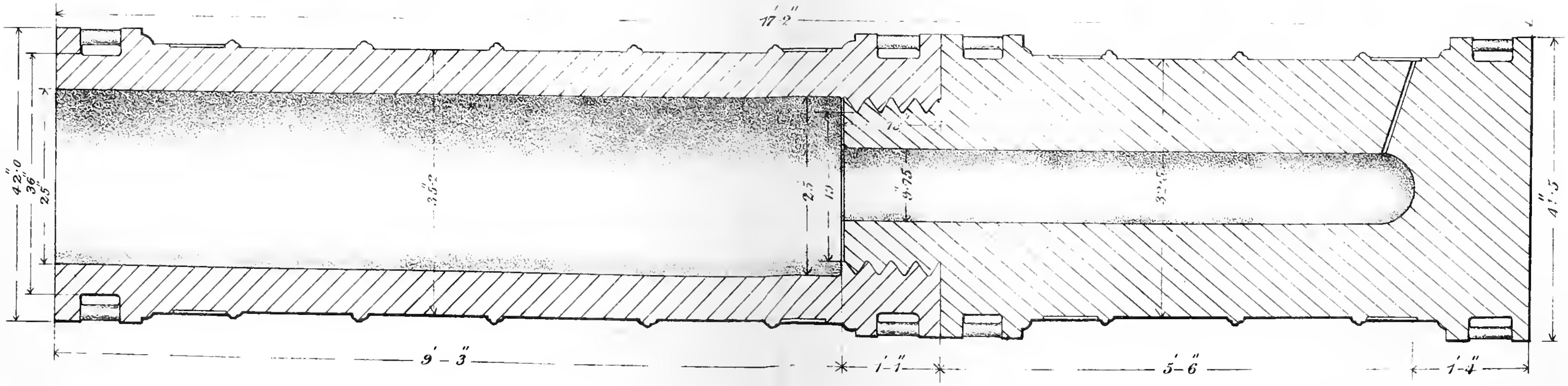
Scale $\frac{1}{24}$th

BREECH FROM PHOTOGRAPH





LONGITUDINAL SECTION.



Lithographed at the Royal Artillery Institution.

PL I.

AN ACCOUNT

OF THE

GREAT CANNON OF MUHAMMAD II.

RECENTLY PRESENTED TO THE BRITISH GOVERNMENT BY THE SULTAN, WITH NOTICES OF OTHER GREAT ORIENTAL CANNON.*

BY

BRIGADIER-GENERAL J. H. LEFROY, R.A., F.R.S.

The great cannon of the Dardanelles have been a subject of wonder to travellers and of interest to artillerymen from the earliest period. There are no other examples of guns which have remained in use for four centuries, and are still, in a very real sense, effective pieces of ordnance. They testify to the former energy and power of the Ottoman race, as no other military monument does, and remind us of an event which has had a greater influence on the politics of Europe than almost any other within the same period—the fall of Constantinople. Monuments of the military genius of Muhammad II. they remind us also of "the splendour and the havoc of the East" by their prodigious size, and cost, and power. They form a class apart, and although there is reason to think that they are referable to a Flemish original, they bear the stamp of a national character and of an epoch of conquest of which European history presents scarce any other example. These cannon were formerly very numerous. M. Thevenot (1655) did not land at the Dardanelles, but as he passed he could "privately discern, with a Perspective glass (on the European side) about twenty Port-holes level with the water, in which there are guns of such prodigious bore, that besides what I could observe by my glass, I was assured that a man might easily creep into them," the other castle (on the Asiatic side) he remarked "hath not so many gun holes." Bishop Pococke, writing about 1740, reckons about 42, viz. on the north side of the Dardanelles 22, on the south 20. His description of them is all the more interesting as there can be no doubt that the gun with the *fleur de luces* is the identical gun which we have lately acquired. It is as follows:—

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* Substance of a Paper read before the Archæological Institute, June 1868.

"There are fourteen large brass cannon without carriages on the sea shore; they are always loaded with stone ball, ready to sink any ship that would offer to pass without coming to anchor, in order to be searched; they fire likewise with ball in answer to any ship that salutes the castle, as this does much damage where they fall, so the lands directly opposite commonly pay no rent. There are eight other cannon towards the south; I saw among them two very fine ones, one is twenty-five feet long, and adorned with *fleur-de-luces* which they say was a decoration anciently used by the Emperors of the East before the French took those arms, and I have seen them in many parts; the other cannon is of brass, twenty feet long, but in two parts, after the old way of making cannon of iron of several pieces; the bore of this is about 2 feet, so that a man may very well sit in it, two quintals and a half of powder are required to load it, and it carries a ball of stone of 14 quintals.*

"The other castle called Rumeli Eskihissar (the old castle of Romelia) has in it twenty large brass cannon, one of which is of great size, but not so large as that on the other side."

A more recent Prussian traveller, Major von Molke (1829), says that there are "63 kamerlicks or guns which throw stone balls, some of which weigh 1570 lbs. weight." "These gigantic guns," he adds, "are some of them 28 inches in diameter, and a man may creep into them up to the breech. They lie on ground on sleepers of oak, instead of gun carriages, and their butts against strong walls, so as to prevent recoil, as it would be impossible to run them forward in action. Some of them are loaded with as much as 1 cwt. of powder."†

1570 Turkish chekies are equivalent to about 1050 lbs. avoirdupois, a stone shot of this weight would have a diameter of 31·7 inches; as the largest calibre mentioned by this officer, 28 Prussian inches, is equivalent to only 28·8 English inches, it is possible that the stone shot of 1570 (Turkish) lbs. were intended for a gun not seen by him, but the discrepancy is not greater than may arise from the vagueness of the original unit, the kantar, when applied to stone shot; of the primitive mode of mounting which he describes, we have many examples.

At the present time there are but 18 of these guns left, including the one recently presented to Her Majesty, and I am indebted to Mr Wrench, H.M. Vice Consul at the Dardanelles, for being enabled to give a list of them; it includes three that have been recently broken up.

N, signifies that the gun was, in January, 1868, in the Fort Kilit Bahar on the European side of the Dardanelles Straits.

S that it was in the Sultanieh Fort of Chanak Callessi, on the Asiatic side of the Dardanelles Straits.

Many of the guns have the weight of shot marked in kantars only, I have reduced these to okes, at 44 okes = 1 kantar. In others it is marked in okes, not in kantars.

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* A quintal is 110 rotoli of 144 drams, or 1·00 lbs. avoirdupois according to some authorities. Tate makes the Rotolo 180 drams or 1·27 lb. (Modern Cambist).

† Mallet. von Hammer says (II. p. 514), *Moi même j'en ai vu un aux Dardanelles: sa bouche éte si vaste, que peu de temps avant mon arrivée, un tailleur poursuivi pour dettes, s'y était blotti et y resté caché pendent plusieurs jours!*

TABLE I.

LIST OF GREAT TURKISH GUNS EXTANT IN 1868.

No.	Place.	Date.		Designation in kantars.	Dimensions.			Modern Turkish charge.			In English measures.		Remarks.
									Shot.				
		A.H.	A.D.		Cal.	Diam. of chamber.	Length.	Powder okes.	Kantars.	Okes.	Charge of powder.	Stone shot.	
					in.		ft. in.				lbs.	lbs.	
1	N	—	—	10	29·5	—	14 5	25	10	440	70·7	1245	
2	N	—	—	10	29·0	—	14 2·5	25	10	440	70·7	1245	
3	N	—	—	8·5	27·5	—	13 10	20	8½	374	56·6	1058	
4	N	—	—	8	27·0	—	14 1·5	20	8	352	56·6	996	
5*a*	N	—	—	8	26·7	—	12 4·5	20	8	352	56·6	996	
6	N	—	—	7	26·5	—	13 10	20	7	308	56·6	871	
7	N	—	—	5·5	26·0	—	14 0	16	5½	242	45·3	685	
8*b*	S	928	1521	5	25·5	9·5	15 6	17·5	—	240	49·5	670	The work of Ahmet, son of Abdul, the chief gunner.
9*c*	S	928	1521	5	25·0	9·5	15 7	17·5	—	240	49·5	670	
*10**	S	*868*	*1464*	*5*	*25·0*	*10·0*	*16 7*	*17·5*	—	*240*	*49·5*	*670*	The work of Munir Ali.
11*d*	S	—	—	5	25·0	9·5	14 0	17·5	—	240	49·5	670	
12*e*	S	928	1521	4·6	23·5	9·7	14 0	16	—	220	45·3	620	The work of Mustapha, son of Murad, the chief gunner.
13	S	—	—	4·5	22·5	—	16 0	16	4¼	198	45·3	—	
14	N	—	—	4·2	22·5	8·1	12 9·5	15	—	200	42·5	564	
15*e*	S	863	1458	3·7	23·2	8·5	12 8	13	—	176	37·7	498	The work of Khoder.
16	N	—	—	3·5	20·5	—	—	12	3½	156	34·0	—	
17	N	—	—	3·5	20·7	—	11 11	12	3½	156	34·0	—	
18*f*	S	—	—	3·2	21·2	8·7	10 7	12	—	154	34·0	436	
19*f*	S	—	—	3·2	21·0	8·7	11 4	12	—	154	34·0	436	
20	S	—	—	3·2	20·0	7·0	12 4	12	—	154	34·0	436	
21	N	928	1521	2·5	19·5	—	11 2·5	10	2½	110	28·3	—	The work of Mustapha, son of Murad.

a By a clerical error the bore of this piece is returned at 20·7 inches, for a shot of 8 kantars.

b This gun is still constantly fired. It is marked by 11 shot. It bears a second date A.H. 1126 = A.D. 1714., the epoch of preparations for war with Venice, when its weight, length, and weight of shot were inscribed.

c This gun bears the marks of having been struck by 6 shot.

d This gun is marked by one shot.

e Nos. 12, 14, and 15, have been recently broken up.

f Nos. 18 and 19 stand sentenced to be broken up.

* This is the gun lately presented to our Government, of which a fuller description and drawing

Mr Redhouse reads the inscriptions on Nos. 8, 9, 12 and 21 (of which a careful copy will be found on Plate V.) as follows:—

The first line is in Persianized Arabic, Persian, and Turkish, the last two in Arabic, the engraved inscription in modern Turkish.

DATE A.H. 928, A.D. 1521-22.

"The work of Mustafa son of Murad, Chief Gunner."

"And in the time of Sulayman Shah the just."
"I made the guns for the destruction of Forts."
"The chronicler said of the great gun, 'This is one of the houses, judge thou then as to the palaces.'

"The last line," he adds, "is an allusive quotation. The letters added together in their numeral values should give the date, but do not in any way I can see. The quartet is a chronogram, but a false one. There are several mistakes made by the moulder, or the copier, which I have indicated; all the long inscriptions are verbatim copies of this."

This difficulty as to the chronogram has given an extraordinary amount of trouble. There seems to be certainly a mistake in the work, Mr Wrench wrote in May last.

"The inscription which has been puzzling me in common with the scribes here for so long a time is not even yet satisfactorily deciphered. I went some little time ago with one of the most learned men here, and we copied the inscription, as I thought exactly, as it was on the gun; this copy I sent to Mr Hughes our Oriental Secretary at the Embassy, and at a meeting I had with Mr Hughes and a learned friend of his it was shown that my copy could not possibly be correct, as the date in figures did not correspond with that in characters. They advised me to send a rubbing of the inscription, and I am in a day or two going to take one, when I sincerely trust a satisfactory result will be obtained."

I have already observed that only two of these guns are referable to the period of Muhammad II., and although we have none exactly contemporaneous with the fall of the Byzantine Empire, one of those that have been lately broken up (No. 15) carries us to within seven years of that epoch. The interest attaching to them has been very much enhanced by the discovery at Constantinople within these few years of a work in MS. by a contemporary writer named KRITOBOULOS, in which he describes the actual fabrication of the first of Muhammad's great cannon. A part of this MS. has been

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will be found at p. 214. There are only two guns of the foregoing list which date from the reign of Muhammad II., and one of them is already broken up. We possess the other. There are four of the same date, A.D. 1521, one year before the conquest of Rhodes, and possibly among those which were cast on the Island for its subjection before the siege of the Fortress, which fell Dec. 22, 1522. These four guns, Nos. 8, 9, 12, and 21, bear the same inscription, which has been deciphered by Mr Redhouse, a task of which the difficulty can only be fully appreciated by Oriental scholars; but having seen educated natives entirely baffled by them, I may venture to call the attention of artillerymen to the great obligation we are under to this eminent scholar for his having on many occasions brought his great learning to bear on so apparently trivial a subject as the inscription on a gun, at the cost of not a little time and research.

translated into French by Dr Déthier, Director of the Austrian College at that place, and through the kindness of Mr Newton, of the British Museum, I have had access to this work, and can present a translation from it. It bears date 1467, and the portion published by the learned Doctor commences thus:—

"After having distributed his troops around the walls of Constantinople (1451), Muhammad II. summoned the makers of his ordnance and discoursed with them on the Guns, and on the Defences, and what manner of cannon he needed the better to beat down the walls. The gunners replied that it would be easy to make a breach if they could make on the spot out of the guns they then possessed others large enough to overturn and demolish the rampart; but that to cast such pieces a considerable outlay was necessary, and above all a large supply of bronze. Muhammad commanded at once that they should have everything they required, and on their part they made the machine (cannon), a thing terrible to look upon, and not to be believed by the hearer. But I will now explain the mode of fabrication, and the form and the use of it. They take a quantity of very fat clay, the purest and lightest possible, which they make plastic by kneading it for several days. The mass is knit together and prevented from breaking by the intermixture of linen, hemp, and other shreds, and the whole well worked up and well mixed in such a manner as to make one tough and compact mass. Then they make a round cylinder, *en forme de flute*, very long, to be the mandril or core of the shape. It was 40 palms in length, the front portion of gun proper was 12 palms in circumference. The rear portion, that is to say the chamber intended for the reception of the powder (*l'herbe*), was four palms, or a little over, in circumference, according to the rule of proportion to the rest of the gun, that is to say one-third.

"Another exterior shape, to receive the first, was next made ready, hollow and as if intended for a sheath to the first; but be it observed, larger, and not alone to receive the other, but such as to leave a void space between the two. This space or this interval all round, between the surfaces, which is uniform, is a palm or a little more. It is the space intended to receive the bronze pouring into it from the furnace to take the form of a cannon. This exterior is made of the same description of clay, but entirely surrounded and fortified with iron, timber, earth and stones, built up round it, and intended to prevent the immense weight of the bronze from fracturing it and spoiling the cannon. Then they erected two furnaces, one on either side and close by for the foundry. These towers were very strong and fortified internally with bricks and a very fat well-worked clay, and on the outside surrounded with large cut stones and cement, and everything suitable for adding to their strength. And they cast into the foundry a mass of bronze and tin, about 1500 talents. Thereupon they threw in charcoal and wood, and so disposed it that the metal was covered above and below and on all sides, and the very furnaces hidden except their outlets. Round about this were the bellows which worked without rest or intermission when the mass was once lighted, and this for three days and three nights, until the whole of the bronze melted down and liquid became as water. Then the outlets having been opened the bronze poured through earthen pipes into the mould until it was filled and the interior cylinder covered, and the metal one pic in depth above it. The cannon was then cast.*

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* A Turkish pic is 27·9 ins. If we may trust Baron de Tott, they continued to cast their guns hollow till the middle of the last century. "All the work was done in common furnaces, and the bronze burnt by the action of the bellows, and then cooled at the bottom of the basons, reached the moulds in a state of paste, their defective nature adding to the imperfection of the piece

"When the bronze had contracted and cooled down the exterior and interior moulds were taken away, and the metal, which was scraped and polished, glittered on all sides. So much for the fabrication and form of the cannon.

"Now I will explain to you how it was made use of.

"First they put into it that which is called the powder, filling the chamber behind completely, up to the mouth of the enlarged part of the bore which is intended for the stone shot. Then they introduced a great stopper (*bouchon*), a lid (*couvercle*) of wood, and very strong, which they batter down with iron rammers so that it shall closely confine the powder after such sort that nothing can dislodge it if it be not the force of the enflamed powder; then they placed the stone upon it, ramming it down with force so as to make it enter into the wooden stopper and make a round cavity.*

"After this, having turned the cannon towards the object intended to be struck, and given it an angle of inclination according to the rules of their art and of like cases, they brought great beams of wood which they laid under it, and on top and on all sides so that it might not be disturbed and strike wide of the mark, by the effect of the shock and the recoil. After all this they applied the fire to the little orifice behind, making a train of the powder. This lighted quicker than thought, first ensued a terrible muttering, and a shaking of the very ground beneath and around, and a strange noise; then with a lightning flash, a horrifying uproar and a flame scorching and blackening all around, the stopper borne on by the strong hot breath thrust the stone forcibly forth and issued from the gun. Borne by an irresistible force and energy this latter struck upon the wall and instantaneously broke it, knocked it over, shattered it and crumbled it into a thousand fragments. By sending pieces in all directions it scattered death all over the neighbourhood. Sometimes it knocked down all one section of the wall, sometimes half of it, sometimes more or less of one of the towers, or the great wall between two towers, or the battlements. There was nothing so hard, or so mighty, or so heavy, even in the strongest wall, as to be able to resist a shock like this, or ward off such a missile.†

"Thus inconceivable and incredible is the nature of this machine. The ancient princes and generals did not possess and had no knowledge of such a thing. For if they had had it no city could ever have resisted their attack, and they would not have had such trouble to breach and destroy their walls, and the very strongest would have been no obstacle to them. They were obliged to raise mounds against them, to gird them with trenches and lines of circumvallation, to dig mines and galleries to get below the walls, and to do many like things all to make themselves masters of cities or fortresses. With cannon all this would have been done quicker than thought, they would have easily battered and overturned the walls, but they had them not. It is a new invention of the Germans or of the Kelts made about 150 years ago, or a little more. It is an ingenious and happy discovery, especially the powder, which is a composition made of the element most hot and most dry:

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produced. I proposed to establish a reverberatory furnace, and a boring machine. The idea of casting without bellows, of casting solid, and then boring, provoked the laughter of the Turkish founders."—De Tott's *Mémoires,* about 1790, pt. III. p. 98.

* This proves that the wad was raised at the edges, and concave.—*Author.*

† A French writer quoted by the Emperor Louis Napoléon, in the "Etudes sur le passé et l'avenir de l'Artillerie," II. p. 95, and who was present, (he does not name him), describes the defences of Constantinople as follows:—"Les murs devant le Turc sont très gros et hauts, et dessus y a barbacanes et machicoulis, et en dehors faux murs et fossés, et sont hauts les murs principaux de 20–22 brassées, et larges, en eaux (haut), en aucun lieu 6, et en aucuns lieux 8 brassées. Les faux murs en dehors ont le terrain haut de 12 brasses, le mur dessus, haut de 14 brassées et gros de 3 brassées. Les fossés sont larges de 26 brassées et profonds de 10."

> of saltpetre, of sulphur, of charcoal, and of *herbs*, from the which composition is generated a dry hot gas, which being inclosed in the narrow rigid and unyielding body of bronze, with no other means of escape than the one left it, opens this by its internal pressure and gives such velocity to the stone that sometimes the very bronze is ruptured. For the rest, our old language has no word to designate this machine unless you choose to call it ἕλιπολος, Taker of cities; or ἀφέτεριον, The bolt-compelling. In current language now-a-days all the world give it the name of σκεύη, Machine, bagage. So much for the description of this cannon, as we have been able to learn, seeking the information among those who make a profession of Artillery."

This finishes the Greek writer's account.

Dr Déthier, the learned translator of the unpublished MS. into French, proceeds to draw a comparison between the gun of Muhammad and the American XX-in. Rodman gun, which is of no great interest; but he subjoins a further extract from the same MS. in support of the claim of Muhammad II. to the first employment of vertical fire. "After having given," he says, "an interesting account of the attack on the chain and vessels which defended the entrance of the Port of the Golden Horn, and the necessity the Turkish Admiral Baltoglou was under to retire without any result:" the author proceeds:—

> "But the Emperor Muhammad beholding the repulse of this attack, turned his attention to the invention of another machine. He called together those who made his guns and demanded of them if it were not possible to fire upon the ships anchored at the entrance to the port, so as to sink them to the bottom. They made answer that there were no cannon capable of producing such an effect, adding that the walls of Galata hindered them on all sides. The Emperor then proposed to them a different mode of proceeding and a totally new description of gun, of which the form should be a little modified so as to enable it to throw its shot to a great height that in falling it might strike the vessel in the middle and sink her. He explained to them in what manner, by certain proportions calculated and based on analogy, such a machine would act against the shipping. And these on reflection saw the possibility of the thing, and they made a species of cannon after the outline which the Emperor had made for them. Having next considered the ground, they placed it a little below the Galata point on a ridge which rose a little opposite the ships. Having placed it well and pointed it in the air according to the proper calculations, they applied the match and the mortar threw its stone to a great height, then falling, it missed the ships the first time and pitched very near them into the sea. Then they changed the direction of the mortar a little and threw a second stone. This, after rising to an immense height, fell with a great noise and violence and struck a vessel midships, shattered it, sunk it to the bottom, killed some of the sailors and drowned the rest, only a few saved themselves by swimming to the other ships and nearer galleys."

KRITOBOULOS affirms that the order to make the mortar was given four or five days before the Latin fleet arrived—that is to say, about the 17th April; and we learn from NICHOLAS BARBARO[*] that a Genoese ship was sunken by a bombard on the 5th May, leaving only eighteen days for the manufacture of the piece, a period that seems hardly sufficient, even allowing for the terrible stimulus which must have been given by the chastisement of the Admiral Baltoglou to all who had the orders of Muhammad to execute.

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[*] See von Hammer.

The Turkish habit of casting great ordnance on the spot where they were wanted shews an extraordinary energy and readiness. In the first siege of Rhodes, 1480, Muhammad caused sixteen great pieces to be cast, called basilisks or double cannon, 18 ft. long, and carrying a ball of 2 or 3 ft. diameter,* and here also we are told that their mortars "threw stones of a prodigious size, which flying through the air by the force of powder, fell into the city, and lighting upon houses, broke through the roofs, made their way through the several stories, and crushed to pieces all that they fell upon; nobody was safe from them, and it was this kind of attack that gave the greatest terror to the Rhodians."—*Vertot.*

There is some little difficulty in determining the actual size of the gun cast by URBAN, nor is it clear whether our description relates to that gun or to another. Gibbon states that the great cannon was flanked by two fellows of almost equal magnitude, one of which is described by a contemporary writer Leonardus Chiensis, as throwing a stone ball of eleven palms (104·5 ins.) in circumference; he measured the shot, *Lapidem, qui palmis undecim ex meis ambibat in gyro.* This would give a diameter of about 33·2. But it is further stated by all authorities that the great cannon was cast in Adrianople, whereas our account seems to refer to one cast in front of Constantinople. "At the end of three months Urban produced a piece of brass ordnance of stupendous, and almost incredible, magnitude; a measure of twelve palms is assigned to the bore, and the stone bullet weighed about 600 lbs." He adds, "that it took two months to transport it from Adrianople to Constantinople, a distance of 150 miles." Here again Phranzas steps in with a correction, and says the shot weighed 1200 lbs. *Lapide in eâ estimatione mille ducentarum librarum,* and mentions as an eye witness that was drawn by 50 oxen to Constantinople. It is probable therefore that the statements relate to different guns. Assuming however that one of the guns fired stone shot of 1200 lbs., we have still to enquire what the *pound* was. The most reasonable supposition is that it was the weight now known as the CHEKIE, which is nearly the Roman pound; if so, the shot of 1200 chekies weighed about 804 lbs. avoirdupois, corresponding to a diameter of 25·6 ins. The piece would, in fact, have been a piece of seven kantars.

In regard to its weight, Muhammad we are told delivered 1500 talents of bronze to the founders, but we are met by the same difficulty of determining what the talent was, or rather which of its many values to select. If the Roman talent was carried to Byzantium, as seems probable, and remained in use to the 15th century, we may assume that it equalled 57·6 lbs. avoirdupois, and this agrees with the statement of Leonardus Chiensis quoted by Mr Gibbon,† that the talent equalled 60 minæ, or nearly 60 avoirdupois pounds; on the other hand it is expressly stated by von Hammer that "*le talent pèse cent vingt cinq livres.*" (Livre XII. N.V.) or in fact, the same as the kantar.

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* Relation de Merry de Dupuy, quoted by VERTOT, "Hist. of Knights of Malta," I. 373.

† See Mr Mallet, in "Engineer" of Aug. 21, 1868. "The attic talent weighed about 60 minæ or avoirdupois pounds (see Hooper on ancient weights and measures): but among the modern Greeks, that classic appellation was extended to a weight of one hundred, or one hundred and twenty-five pounds (Ducange, τάλεντὸν)." Milman's Gibbon, 1839, xii. 192. Ducange gives examples of TALENTUM pro Centum libris: pro 50 libris: pro *Libra* et Marca: but not for 125 lbs,

For purposes of rough calculation we may assume the talent intended as equivalent to our half-hundred weight, when the quantity comes to 37·5 tons, some allowance must be made for *dead-head* and unavoidable waste, and we cannot expect from this quantity a gun weighing more than 32 tons, which is perfectly irreconcileable with a bore 34·5 inches or 12 palms in circumference. Such a gun if made of the other dimensions stated would, in fact, weigh over 100 tons, a bulk beyond the bounds of credibility, and we must be content to know that the Turks had in the 15th century guns discharging stone shot of more than 33 ins. diameter, the authority of contemporary writers being supported by the existence of two guns of a size not much inferior, namely 29 ins. and 29·5 ins. to this day; the other particulars of their length and weight are open to question.

It is evident that our gun was cast on its face, the dead-head being left at the breech end and hewn off with axes, probably while the metal was hot. The axe marks are plain; similar marks may be observed on other early guns which have the breech cut off square, for example, No. 201 of the catalogue of the Museum, which is dated A.H. 937, or A.D. 1530.

I have already referred to the singularity of guns three or four centuries old taking part in modern engagements. The most memorable instance of this was afforded in the passage of the Dardanelles by Sir John Duckworth's squadron in March 1807, when the following vessels were struck:—

"CANOPUS." Wheel carried away: hull much damaged; 3 seamen wounded.

"REPULSE." 10 killed and 10 wounded by one stone shot from the Asiatic side.

"ROYAL GEORGE" (Sir J. Duckworth). A stone shot stuck fast in her cutwater. It is not stated what damage was due to this projectile, but she lost 3 killed and 27 wounded.

"WINDSOR CASTLE." Mainmast nearly cut in two by a stone shot of 800 lbs. She lost 3 killed and 13 wounded.

"STANDARD." Struck by a stone shot from Sestos of 770 lbs., 26 ins. in diameter, which killed 4 men and led to a succession of disasters by which 4 more lost their lives, and 49 were wounded.

"ACTIVE." Was struck by a granite shot 78 ins. in circumference, and said to have weighed 800 lbs., but no one was hurt. It was this shot that made so large a hole in the side that the Captain, looking over to see what was the matter, saw two of his crew thrusting their heads through it at the same moment.

There is an exaggeration about the weight of the last shot, perhaps the boatswain put his foot in the scale; a ball 78 ins. in circumference will be rather under 25 ins. in diameter, and not weigh more than 760 lbs. There are two of these stone shot preserved at the Tower, one of them 24·5 ins. in diameter weighs 744 lbs.; the other 19·7 ins. in diameter, weighs 586 lbs. The shot which accompanied the gun to be described, average 75·7 ins. in circumference, or 24·1 ins. in diameter, and weigh 672 lbs. very uniformly; their material is granite.

One of the most interesting documents that has come down to us is an account, given in one of the notes to von Hammer's History, of the pieces of ordnance placed in battery against Scutari, in Albania, in 1478. There are no less than 11 guns enumerated,* throwing stone shot increasing in weight from 3 to 13 kantars; now the kantar is a well-known weight equivalent to 44 okes, each oke 2·83 lbs. avoirdupois, consequently the kantar is equal to 124·5 lbs. avoirdupois. Upon this datum I have constructed the following Table. It will be observed that there are only two exceeding in size those actually known to us, and that the calibres follow pretty closely the scale afforded by the guns now extant, as given in Table I.

Table II.

GUNS PLACED IN BATTERY AGAINST SCUTARI, IN ALBANIA, BY MUHAMMAD II., A.D. 1478.

Cannon shooting a stone shot of kantars.	No.	When ready, 1478.	Diameter of stone shot.	Probable diameter of gun.	Weight of shot.
			″	″	lbs.
3	1	22 June	19·8	20·8	373
4	2	22 ″ 26 ″	21·8	22·8	498
6	2	6 July 8 ″	24·9	25·9	747
6½	1	26 June	25·6	26·6	810
7	1	7 July	26·3	27·3	871
9½	1	11 ″	29·0	30·0	1182
12	5	6 ″ 7 ″	31·4	32·4	1494
13	1	8 ″	32·4	33·4	1640

We are further furnished with a return of the number of shots fired each day, which I subjoin:—

Date 1478.	Guns in battery.	Fired shots.	Date 1478.	Guns in battery.	Fired shots.	Date 1478.	Guns in battery.	Fired shots.
June 22	2	7	July 2	4	35	July 12	11	187
″ 23	2	9	″ 3	4	44	″ 13	11	183
″ 24	2	8	″ 4	4	47	″ 14	11	168
″ 25	2	7	″ 5	4	4	″ 15	11	187
″ 26	4	29	″ 6	6	42	″ 16	11	182
″ 27	4	28	″ 7	8	57	″ 17	11	194
″ 28	—	—	″ 8	10	42	″ 18	11	131
″ 29	4	1	″ 9	10	76	″ 19	11	193
″ 30	4	34	″ 10	10	104	″ 20	11	148
July 1	4	36	″ 11	11	178	″ 21	11	173
							Total ……	2534

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* Von Hammer, III. p. 42. He quotes Barletius.

Thus it appears that towards the end of the siege these great cannon discharged 16 shots a day each, a number which indicates a very tolerable degree of manageability. At the risk of being tedious, I cannot but remark on two other points. First, the immense supply of gunpowder required, and its sources. We are not precisely informed of the charges, nor is the precise constitution of Turkish gunpowder at this period known; but we know the proportions of European gunpowder a little later, it consisted of—

Saltpetre......................	4 parts.
Sulphur.......................	1 〃
Charcoal......................	1 〃

and I take the charge at one-fourth the weight of the shot; on this estimate nearly 250 tons of gunpowder must have been consumed, requiring for its manufacture about 167 tons of saltpetre. Montecuculi, speaking of the Turk as he knew him about 1660, remarks, "He works incessantly at the production of gunpowder in every place on the frontier. He gets it from Cairo and Egypt; he buys it of the Christian, and he has such an abundance of it that he consumes more in useless firing and display than we do in necessary services. When he is conducting a siege, or in a campaign, they cry every evening during the hour of public prayer *Halla, Halla* (Allah), and after this cry they fire a general salvo of what ordnance is to be found in the trenches, in the lines of approach, and in other parts of the camp. This occurs every day. It is easy to see what a consumption there must be of ammunition. For the rest, their powder is excellent, as appears by the noise of the report, the force, and the reach of the shot (*longueur des coups*)."* A similar barbaric abundance, and doubtless waste, must have characterized their employment of gunpowder from the very first. I imagine that this supply must have been obtained, as the Turks have obtained it at later periods of their history, by levying a tax to be paid in saltpetre over whole provinces. Nitrate of potash is produced in an impure state pretty extensively in warm climates, and the production may be augmented by artificial means. It would be interesting to discover how the receivers discriminated between this salt and others very like it.

The other observation I have to make, relates to the provision of stone shot. Upon the supposition that the guns all fired alike and in total proportion to the number of days they were in battery, the expenditure will be about as follows:—

Shot of	19·8	inches or	373	lbs.	310	Shot of	26·3	inches or	871	lbs.	190
〃	21·8	〃	498	〃	580	〃	29·0	〃	1182	〃	190
〃	24·9	〃	747	〃	420	〃	31·4	〃	1494	〃	400
〃	25·6	〃	810	〃	230	〃	32·4	〃	1640	〃	214

Total 2534.

The whole weighing about 1000 tons; now the transportation of 1000 tons of stone shot with the army, is out of the question. They must have been cut on the spot, and one is lost in astonishment at the prodigious

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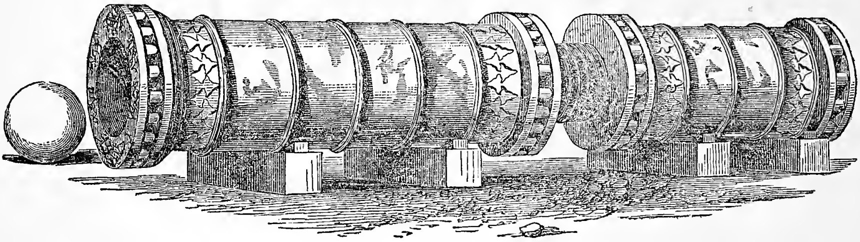
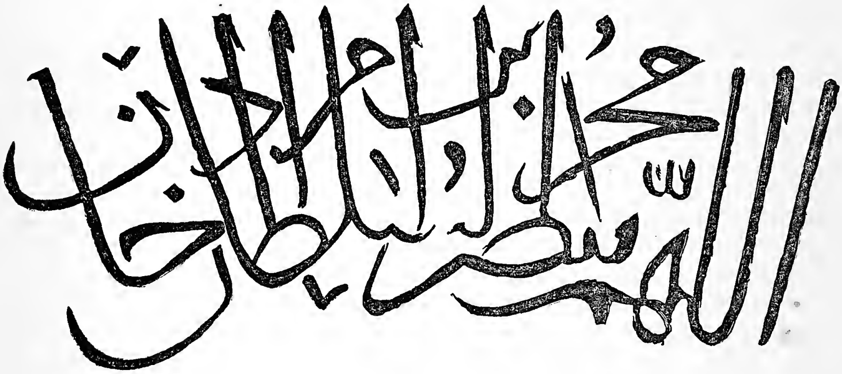
* Memoires, &c, Montecuculi, I. Bk. II. Ch. ii.

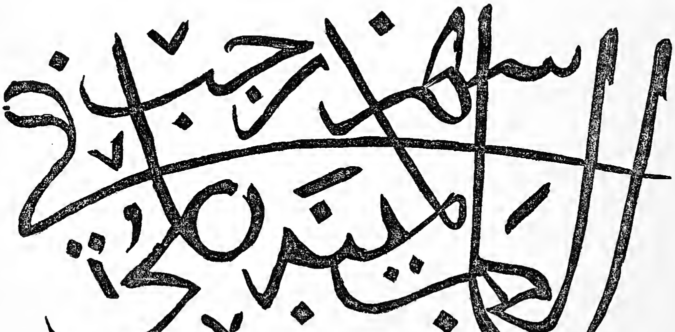
labour of quarrying the blocks and cutting them into spherical form. A single shot of 24 inches offers 12½ square feet of surface to be dressed, and they are generally extremely well cut. The misery of the wretched slaves condemned to this labour must form a heavy item in the huge aggregate of human suffering which lies to the charge of Muhammad the Conqueror.



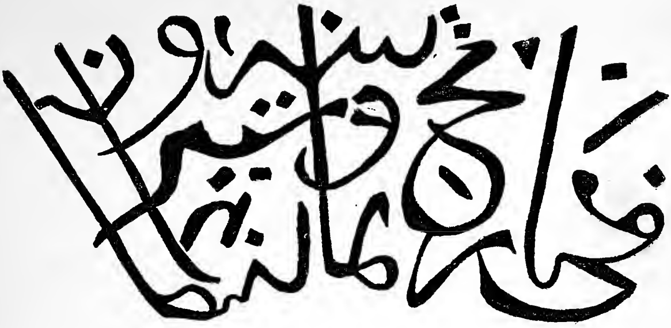
The gun recently received at Woolwich, of which the above is a wood-cut, bears the following inscriptions:—



(1) Help, O God. The Sultan Muhammad Khan, Son of Murad.



(2) The work of Munīr Alī in the Month Rejeb.



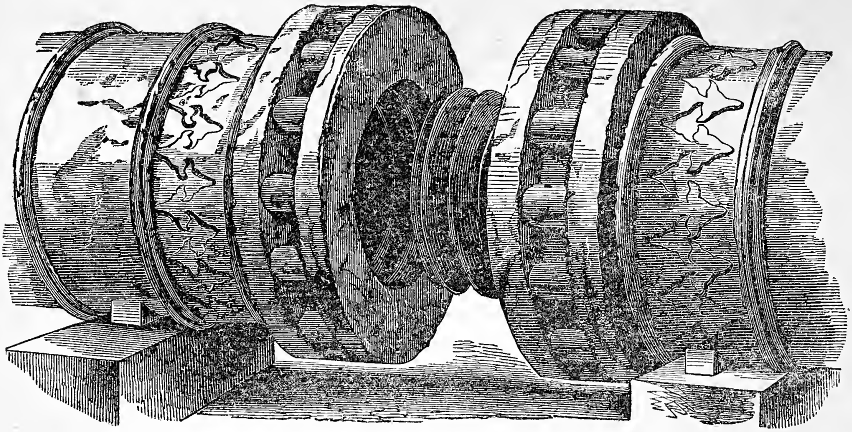
(3) In the date of the year eight hundred sixty eight.=A.D. 1464.

The extremely intricate character of Turkish caligraphy, introduces some uncertainty into the proper name. Mr Redhouse, who at first read it Munēr, was then inclined to prefer Minbir, a word which signifies Pulpit. His excellency Halil Pasha, Grand Master of Artillery, reads Munir, and Efflatoun Pasha, on recently examining the gun, was equally positive that it cannot possibly be so read, but may be Mēner.

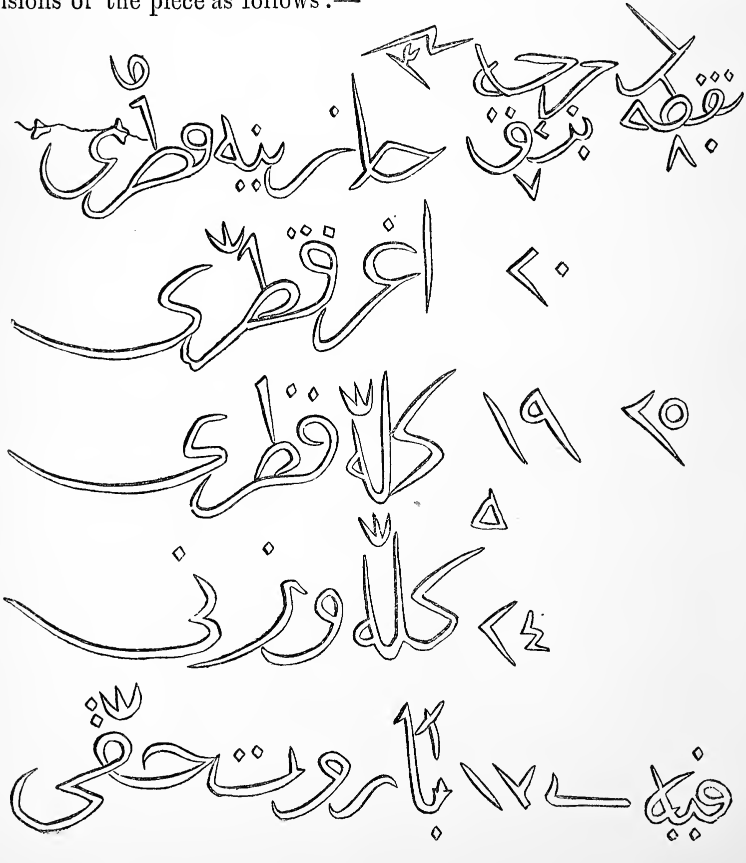
The gun is made in two parts, which screw together, each weighs 8 or 9 tons; no description can do justice to the massive character, the grand simplicity which belongs to this great piece of ordnance. The external form is a cylinder, the muzzle being as large as the breech; but either half is relieved by a boldly projecting moulding at each end, which is divided transversely by 16 cross bars into as many recesses. Considered only as ornaments, these have the happiest effect, but they were made with a design. They answered beyond doubt the purpose of the holes in a capstan head, and were used to give a purchase to the levers employed in screwing the two parts together. A precisely similar provision of capstan holes has often puzzled observers in Mons Meg, and in the great bombard at Ghent. I have no doubt that those pieces also are made in two parts, and screwed together, and although the oxidation of the iron might make it more difficult to unscrew the former than it was found to be to unscrew Muhammad's gun, it might be done.

There is nothing new in the fact of the gun being screwed together, similar examples are referred to by General Favé, *Artillerie*, Tom. 3, p. 168, and engraved by St Remy; but a very considerable degree of mechanical skill and precision was required to cast two screws of 23 inches diameter, which should fit one another, and so to unite such ponderous masses. There is no appearance of tool work; in fact, a tool could only smooth away minor inequalities of surface, and could not alter the distance or pitch of the threads, on which the fit depends. We can only suppose that moulding pieces were first cut in wood and nicely fitted and then applied to the clay moulds.

We have a palpable application of moulding pieces in the ornamentation, called by Dr Pococke, *Fleur de luce,* which will be noticed at each end; the marks where the moulds joined are still to be seen. The only other ornament attempted is the subdivision of the cylindrical part by bold rings or mouldings about 14 inches apart. There is a modern inscription of considerable interest in the neighbourhood of the vent, for a translation of



which I am indebted to the same distinguished Orientalist, Mr Redhouse. It gives the practical rules for the employment of the gun in the situation which it occupied for three or four centuries at the mouth of the Dardanelles. Its modern origin is proved by the small charge of powder laid down, for the chamber was made to hold about 150 lbs. of the powder of the period; but the greater strength of the powder of modern times has made it necessary to reduce the quantity to 49½ lbs. The inscription in question gives the dimensions of the piece as follows:—



نقطه کرچه ٣ ٨٠ بزق ٧ خزینه قطری ٥
٢٠ اغز قطری
٢٥ ١٩ کلّه قطری
٥ ٢٤ کلّه وزنی
قیه ـــ ١٧ باروت حقی

I think it probable that this inscription was cut by the same European, I believe a Prussian Officer, who some 40 years ago was employed by the Porte to mount the guns at the Dardanelles on modern carriages.

3 degrees.

Diameter chamber	7 inches, 80 points,
Diameter muzzle	20 inches,
Diameter shot	19 inches, 25 points,
Weight shot	240 okes,
Due powder	17½ okes,

each of the pieces enumerated in Table I. has one like it; as the more important data are embodied in that table they need not all be repeated, but the most ancient, which is on three guns of the date 1521, is engraved on Plate VII.

The following extracts from the log of H.M.S. "Terrible," Captain Commerel, C.B. details the measures taken by that officer for the embarkation of this ponderous piece of artillery, and the manner in which he unscrewed the two parts.

Jan. 10, 1868. Commenced rigging a pair of sheers outwards, which consisted of two two-decker topsails, with topping lifts of stream chain over lower mast-head and into the main deck port on opposite side.

The same day commenced rigging similar sheers on those topping lifts, two parts of an eight-inch hawser, set taut to the stream anchor, backed with timber, &c.

Jan. 16. Hoisted out 6½ ton gun, and landed it in paddle box boat.

Jan. 17. Hoisted out 12-ton gun, and landed it in same boat.

Jan. 18. Hoisted in the shorter half of the large gun, and the afternoon the longer half.

The fall used was 6½, the blocks, threefold, 24 each.

It was found necessary to unscrew the gun; this was performed by the engineers of the "Terrible," by means of the lever jacks of ten tons, and capstan bars made to fit the holes cast in the gun, a power of nearly 40 tons was used for this purpose.

The gear all closed remarkably well, not a rope yarn strained or spar sprung.

The gear lay on the open beach at Chanak, and was very exposed to the prevailing winds. Three days would have sufficed for the operation if weather had permitted.

It is remarkable that Baron de Tott's description of the *enorme perrier dont le boulet en marbre pesait* 1100 *livres,* like that of Dr Pococke, applies to this gun, and to no other now existing. "*Cette pièce,*" he says, "*fondue en bronze sous le regne d'Amurat, était composée de deux morceaux réunis par une vis, à l'endroit que sépare la chambre de la volée, comme un pistolet à l'Anglaise.*" He relates how he loaded it with 330 lbs. of powder and discharged it. He observed the shot break into three pieces about 600 yds. from the gun, and these pieces crossed the Dardanelles, leaving the surface in a foam where they struck, and went bounding up the opposite shore. He is very vague, or rather says almost nothing, about the other pieces, and his authority for the date of this piece cannot be accepted. Amurath, or Murad II. was the father of Muhammad; he was the first to employ artillery, but it is impossible to transfer to him the credit which history assigns to the son for the invention of these gigantic pieces. In short, Baron de Tott cannot be implicitly relied on for the age or the size of the gun he refers to, which, was beyond a doubt the one we now possess, or for the charge he employed with it. The chamber does not hold half the quantity.

I have observed that Muhammad's cannon were probably copied from a Flemish original. This will appear on comparing our gun with the great Bombard of Ghent, which I am enabled to do with great precision, by the aid of a drawing made by Professor Pole in 1864. The dimensions, allowing for the necessary difference between wrought-iron and bronze, correspond so closely that I cannot believe the resemblance to be accidental, and it extends to the method of construction. In both pieces the powder chamber is in a separate forging or casting, and screwed to the body. Mons Meg presents us with a similar example on a smaller scale. This famous gun, the Dulle Griete, *Marguerite Enragée, Raging Meg,* of mediæval writers, is considered by Favé to be the piece referred to by Froissart in a well-known passage :—

> "Pour plus ébahir ceux de la garnison d'Oudenarde, ils (les Gantois) fierent faire et ouvrir une bombarde merveilleusement grande, laquelle avait 53 pouces de bec, et jettait carraux marveilleusement grand, gros et pesants ; et quand cette bombarde décliquait, on ouiait par jour bein de 5 lieues loin et par nuit à 10. Elle menait un si grand bruit au décliquer qu'il semblait que tous les diables d'enfer fussent en chemin."

There are however two difficulties in this identification, first, from the dimensions he gives, and next from the arms on it. 53 *pouces de bec* cannot possibly be 53 inches of calibre, a wholly incredible size; it doubtless means 53 inches in circumference of bore, measured round the mandril on which the bars were assembled, which as we have seen was a common way of measuring in the 15th century. This corresponds with a bore of 17 inches nearly, whereas the Dulle Griete has 25 inches; then as to the arms, we find round the vent those of the order of the Golden Fleece, which was not instituted until 1430, whereas the event described by Froissart occurred in 1382; it is objected that they may have been engraved after 1452 when the piece fell into the hands of the citizens of Oudenarde (who retained it to 1578), but this is at best conjecture; and the opinion of the highest antiquarian authority at Ghent, is that the piece cannot be anterior to 1430. This is sufficiently early to favour the supposition that Munir Ali, the maker of our gun, was possessed of drawings or particulars of it, easily obtainable through some of the adventurous Europeans who, like Urban the Hungarian,* sold their swords to the highest bidder. The shield of arms is that of Phillipe le Bon, Duke of Burgundy and Count of Flanders, who was born in 1396 and died in 1467.

It is to be regretted that Professor Pole's visit to Ghent was not productive of any of the amusing incidents which attended his previous visit to Mont S. Michel, and of which he gave us so lively an account.† His

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* Τὸ γένος Οὔγγρος, Ducas. Ὀρβάνος Δαξ' τὸ γένος, Chalcondyle. See von Hammer II. 380.

† Vide Vol. IV. p. 14.

drawing, however, leaves nothing to be desired. "The only thing of importance," he wrote, "not shewn on the drawing, is the *damage inside the gun,* on the lower side. From near the inner end of the barrel to within about 21 inches of the muzzle the longitudinal bars have been torn away or greatly damaged I presume by the enormous weight of the ball rolling along. This damage extends over a space 8 or 9 feet long, and 12 to 15 inches wide.

"I calculate the weight of the gun to be nearly 13 tons.

"The weight of the granite ball (24 inches diameter), would be about 700 lbs.

"Naming the gun by its size of bore, it might be called nearly a 2000-pr.

"I calculate the chamber would hold 160 lbs. of powder."

It is impossible not to be struck with the family resemblance of all the great Bombards, it is most apparent on comparing drawings made to the same scale, but I subjoin a Table of their principal dimensions, in proof.

TABLE III.

LIST OF GREAT BOMBARDS NOW OR LATELY EXTANT.

Nature.	Date.	Weight in tons.	Diameter.			Length.		
			Bore.	Chamb.	Exterior.	Bore.	Chamb.	Over all.
			″	″	″	″	″	″
WROUGHT-IRON :—								
English guns now at Mont S. Michel … *A*	Before 1423	* 5·3	19·	5·75	30	94	48	197
English guns now at Mont S. Michel … *B*		* 3·3	15·	5·1	22	80	36	156
DULLE GRIETE, Bombard of Ghent	After 1430	*13·0	25	10· 6·	39	1272	56	197
MONS MEG, Edinburgh ……………	Before 1460†	* 5·7	20	10·	29·5	106	45	159
BRONZE :—								
CANNON OF MUHAMMAD II., Woolwich	1464	18·7	25	10	41·5	110·2	75·8	204·7
MALIK-I-MYDAN, great gun of Beejapore………………………………	1548	*40·	28·5	16	57	93	60·5	170·6
TZAR POOSCHKA, great gun of Moscow	1586	38·5	36·	19	63	122	70	213
DHOOL DHANEE, great gun of Agra …	1628	30·2	23·2	10·5	45·5	108	50	170·2

The sketch on p. 220 represents the present condition of the Malik-i-Mydan or Lord of the Plain, the great gun of Beejapore. It is taken from a photograph by Colonel Meadows Taylor, given in Fergusson and Taylor's Architecture of Beejapore, a magnificent work published in London in 1866, one of a series for which funds are provided by native gentlemen of ancient descent in India, to preserve to posterity the glories of their country. Three have appeared :—

AHMEDABAD, at the cost of PREMCHUND RAICHUND.
DHARWAN AND MYSORE, at the cost of the same.
BEEJAPORE, at the cost of KURSONDAS MADHOWDAS.

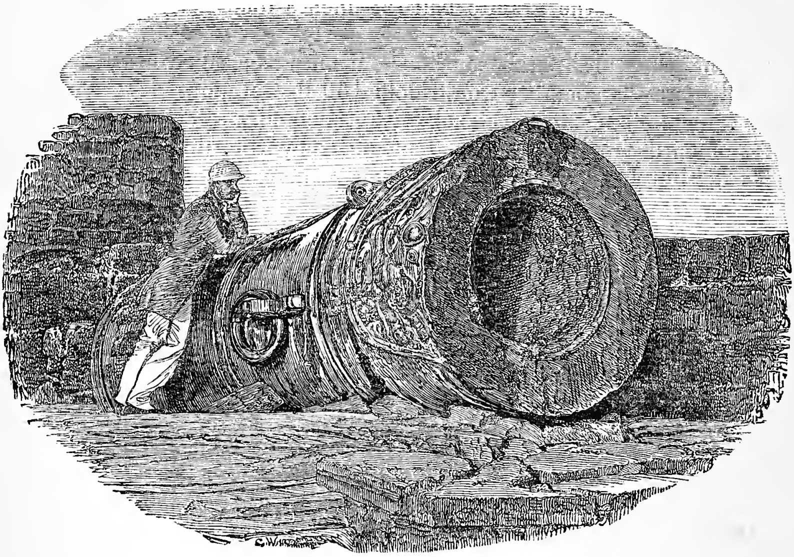
---

* Calculated weights.

† In assigning this date, I am influenced by the belief that the well-known Galloway legend, according to which it was made in 1455, has some foundation in fact, and notes at least the first appearance of Mons Meg. We do not otherwise hear of her before 1489, but there is no indication of the piece being then used for the first time.

The former of these enlightened and munificent patrons paid £2000, the latter £1000 towards bringing out these works, the cost of which absorbed all those sums.

The gun was cast at Ahmednugger in the reign of Boorhan Nizan Shah I. A.H. 956 or A.D. 1548, and we trace the influence of the school of Muhammad no less in the name of the maker than in its form and proportions. It was cast by or under the superintendence of the General of the Artillery, Muhammad bin Hassan Roumi, that is, of Constantinople.



THE MALIK-I-MYDAN.

The following particulars are principally extracted from a memorandum which accompanied a bronze model of the gun made by Captain now General Julius Griffiths, Bombay Artillery, in 1825, and presented by Sir Charles Colville to the Duke of Wellington, by whom it was deposited in the Rotunda. Mr Bird supposed that the Rumi Khan who cast the gun at Ahmednugger, and whose tomb is still to be seen there, was the individual mentioned in the history of Gujerat, who founded the Castle of Surat, A.H. 947, or A.D. 1540. In the disastrous retreat from Kulliani, A.D. 1562, Hosain Nizan Shah abandoned no fewer than 701 pieces of ordnance, at which time the great gun fell into the hands of Ali Adel Shah of Beejapore. When Beejapore was taken by Shah Alumgeer Ghazu* (Aurungzeb) in the reign of Iskander Adel Shah, a new inscription in Persian was added to commemorate the event. The inscriptions in relief occupy a considerable portion of the upper surface of the gun, and are very beautifully executed, particularly the original Arabic, the letters of which are upwards of a foot in length. There are a number of peculiar abbreviations in it, a kind of stenography, where a single letter is made to form part of several distinct letters.

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* Ghazu means conqueror, a title of the Mogul Emperors as warring against and subduing infidels, other versions spell the name of the sovereign Alem Ghir.

The inscriptions are as follows:—

(1) THERE IS NO GOD BUT GOD, AND NONE BESIDE HIM.

(2) Abu l ghazi Nizam Shah-king, servant of the race of the Apostle and of the house of God, 956 (A.D. 1548). This is read as a distich by General Boileau.

> "The servant of the people is the Messenger of God."
> "The slave of the Conqueror is Nizam Shah."

(3) The work of Muhammad Ben Hassan Roumi.

(4) Shah Alum Geer, the victorious king defender of the Faith. He who dispensed just judgment, and took the dominion of Kings, conquered Beejapore, and for the date of the Victory Fortune shewed her face and said, "He hath taken possession of the [master of the] Field." Executed in the thirtieth year of the reign of the exalted in dignity, corresponding to the one thousand and ninety seventh year of the Hegira (A.D. 1685).

The date is made up by adding together the numerical value of 14 letters. Another translation arranges the clauses somewhat differently. Thus:—

"Fortune shewed her face and said, He hath taken the Lord of the Battle Field, that which he dispensed he dispensed justly, and subdued the country of the kings. Shah Alum Geer, the victorious king, defender of the Faith, achieved the conquest of Beejapore, and as to the date of the Victory, in the thirtieth year of his exalted reign corresponding to the one thousandth and ninety-seventh year of the Hegira."

The gun was mounted on an immense iron crutch forming a species of swivel, with the breech resting on a block of wood supported by a thick wall, so that it could not recoil very much, as Muhammad's guns continued to be until von Molke mounted them. The bastion in which it lays bears a grandiloquent inscription.

"During the reign of the victorious king surnamed Ali Adel Shah, to whom by the favor of the Murtuza (Ali), God granted a distinguished victory, this bastion was, in the space of five months, made as firm as the strong mountain, through the fortunate endeavour of the mighty Shah, at which time an angel in delight gave the date of the year, saying, 'The Shirza bastion was without an equal,'" or Hegira 1079 (A.D. 1668).

The superstition of the Hindoos long ago converted this gigantic cannon into an object of worship, and they might be seen placing offerings of flowers and copper coins within the muzzle. It is believed to have been last fired on the occasion of a visit of the Rajah of Sattara to Beejapore in the last century, and the people gravely assert that it caused all the pregnant women within hearing to miscarry. The charge was 80 lbs. of powder. The shot, of which several remain, are made of a fine hard basalt, and weigh about 1000 lbs. It is mentioned in the Journal of the Royal Asiatic Society of Bengal (Vol. I.), that an Italian who served in the Mogul armies under the title of Rumi Khan, had this gun in his park of artillery and used it in several battles, occasionally firing sacks of copper coins out of it. Numerous proposals have been made to transport it to England, and as it is the deliberate opinion of such competent judges as Colonel Meadows Taylor, that notwithstanding its great weight of 40 tons, it might now be taken with comparative ease to Sholapore and thence to Bombay, we need not despair of seeing it one day beside its more ancient brother from the Dardanelles, in the Museum of Artillery.

The Dhool Dhanee or great gun of Agra, cast in 1628, has ceased to exist. It was broken up in 1832 by order of Lord William Bentinck, whose reasons for this measure are fully given in a despatch which by the kindness of the Right Hon. the Secretary of State for India, I have been allowed to extract from the archives of that Department.

Extract, Fort William Military Consultations, dated 16*th April* 1832.

Military Department.

MINUTE, GOVERNOR-GENERAL.

Amongst other objects of curiosity at Agra is, what is called the "great gun." The epithet is certainly well applied, for it denotes the only remarkable quality of this enormous mass of metal, which as a piece of ordnance is ugly, disproportionate, and worthless. Had it been otherwise, had any elegance of form been obvious to the eye, the inventive genius of the East would have given it a place in some eventful passage of Hindoo or Mahomedan history. As it is this gun is not coupled with a single incident to render it an object of the slightest regard to any class of persons. Tradition seems not even to have fabled, by whom, when, or where it was fabricated.

Nor is it in any sense considered a trophy of British prowess. It fell among other artillery into the hands of Lord Lake at the capture of the fortress, but was not in any way interwoven with the occurrences of the siege; it proved valuable however to the captors; the Prize Committee having appraised it, in consequence of the supposed costliness of the metal, at I have heard 70,000 rupees, which sum was paid to them by Government. A few years after its capture, a clumsy attempt was made to send it down to Calcutta, which attempt either failing, or being abandoned on the score of expense, the gun now lies useless and neglected near a petty Ghaut of the Jumna under an angle of the Fort.

Whether or not this gun stands upon the public returns as stock, I do not know: probably a record of the payment to the captors of its estimated value, and of the unsuccessful attempt to remove it from Agra will be forthcoming in some public office. For my purpose, however, the absence of any notice of it on the records is immaterial, if I am right in assuming that the gun, as it lies on the bank of the river, is the property of government. If it be so, and if I have correctly described it as being remarkable only for its bulk, the value of its metal, and the failure of the attempt to remove it, it cannot be worth preserving in its present shape; as it is to be presumed also from what I have said, that no feelings or prejudice will be offended by its being broken up, I really think that an article so valuable, as it is supposed to be, owing to the quantity and quality of the metal, of which it is composed, should not be allowed longer to remain useless at a petty Ghaut.

I propose therefore that the gun be offered for sale at Agra in order to its being melted down, it will not probably bring nearly the prize valuation amount, but if it fetches half that sum, it will be admitted that so much money laid out in the execution of some useful public work will be a clear gain. I shall hereafter have the honor of stating in what manner I would make available the funds which may be realized from the sale of the gun.

With a view of being enabled to estimate the value of the metal with some approach to truth, I shall instruct the Commissioner of Revenue and Circuit at Agra, to employ, with the sanction of the Commandant, Capt. Boileau of Engineers, to separate small specimens of the metal, one to be assayed on the spot, and the other at the Calcutta Mint.

(Signed) W. C. BENTINCK.

CAMP GART,
March 17, 1832.

Captain now Major-General Boileau was accordingly employed to examine the gun, he reported that it weighed a little over 30 tons, and might be worth 32,600 rupees, the valuation adopted by government in 1813, and at which they paid prize money to Lord Lake's army having been 39,250 rupees. Accurate enquiry elicited the fact that about 300 maunds of copper (214 cwt.) were consumed in Agra per month, and that the quantity was not too much to bring into the market, and finally the Governor-General in council directed that it should be broken up into pieces of about 20 seers (40 lbs.) each, and sold by auction at an upset price of 14 annas or 1 rupee per seer. Thus was ignobly dispersed the DHOOL DHANEE, the DISPERSER, SCATTERER, according to some interpreters, but Oriental authorities differ as to the etymology of these words. We are indebted to the careful measurements taken by Captain Boileau before carrying his instructions into effect, for preserving so much as its form and dimensions, which are shewn in Plate IV.

There were no inscriptions of any historical interest on this gun, five lines in Persian on the model record the name of the Shah and perhaps of the maker, and the weight of the piece, without ornament. They are not fully legible, but seem to read as follows:—

IN THE DAY OF SHAH.
SULTAN MUHAMMAD GULISTAN.
——— Weight
——— 19·99
——— Date of year 6,

but we find a notice of it in the native guide book to Agra,—

"One day the Emperor Shah Juhan Ghazu was seated on the Imperial Throne, he commanded who had made the gun DHOOL DHANEE. It was humbly represented the Raja Ujij Chund, Lord of Kunoj. He commanded* Sooltan Muhammad Abd ool Ghufoor of Delhi to make a large gun.

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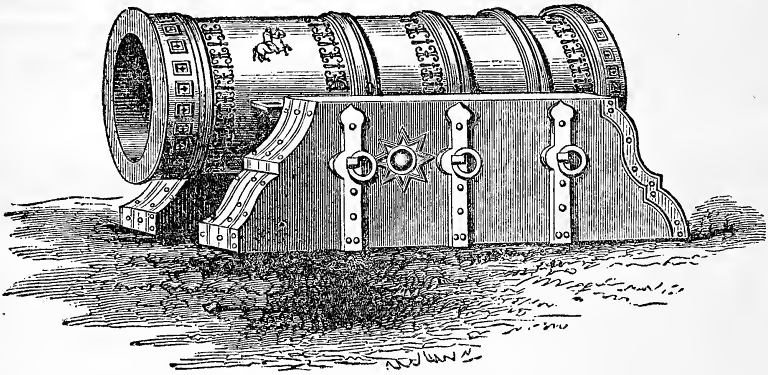
* In the East as n the West, the words spoken by Sovereigns are commands; the King when he speaks never says anything, he always orders, commands.

I am indebted to Major-General Boileau for the particulars of another monster piece of ordnance which rivalled, if it did not exceed, the MALIK-I-MYDAN in size. It was known by the name of ZUFR BUKH, and weighed 1460 maunds, or 52 tons; the account is extracted by him from a pamphlet in the Hindostanee language, published as a guide to the principal objects of interest in Agra, and which was formerly sold by the vendors of objects of art and curiosity in that city. The actual date of fabrication does not appear, but it was anterior to A.H. 1037, or A.D. 1627.

> "Written on the gun ZUFR BUKH,* which was in the Fort.
>
> "The work of the artist† Sooltan Muhammad. Weight of the gun one thousand four hundred and sixty maunds, 6¾ seers.‡
>
> "Afterwards in the time of the Emperor Jalal Ordun. Mohammad Ukbar Ghazu§ the Poor and Vile.||
>
> "Sooltan Muhammad abd ool Ghufoor of Delhi, in the year 1037 of the Holy Hegira wrote.
>
> "The Emperor Juhangur, son of the Emperor Ukbar, conquered the Dukhan by the favor of God."

The last of the guns included in Table II. is in some respects the most remarkable of the whole. It is the TZAR POOSHKA or great gun of Moscow: the largest piece of ordnance, in point of calibre, ever cast.

The annexed figure of it, copied from a vignette in Dr E. Clarke's travels in Russia, shews in what manner it was mounted at the beginning of the present century, but I am indebted to Major-General de Novitzky,



GREAT GUN OF MOSCOW IN 1800.

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* Zufr Bukh.; Victory giving, or the dispenser of Victory.

† The word "Oostad," means a person who is master of his art.

‡ Taking the maund at 81 lbs. avoirdupois, the weight of the gun Zufr Bukh would have been 52 tons, 1 qr. 17·5 lbs.

§ Ghazu is a title assumed by the Emperors, as the Conquerors or exterminators of infidels, like our Crusaders, only that their idea of an infidel embraces every one not a Mahommedan.

|| Fuqeer, Hugeer, and the like, are terms of humility, or mock modesty, used by Orientals (especially Mahommedans), when speaking or writing of themselves—they mean, poor, abject, despicable, vile, contemptible! Not in the sense in which St Paul writes, "Oh! wretched man that I am!"—(*General Boileau*).

Aide-de-Camp to the Emperor of Russia, for the drawing from which Plate V. has been copied, and which represents it on the carriage of the present day; an engraving of the gun is given in a Report of American Officers, 1854.

This great gun possesses also a considerable interest as an example of that skill in the casting and manipulation of great masses of metal for which the Scythian races have been famous from the times of Herodotus downwards. Dr E. Clarke describes it as follows :—

"The great gun, also among the wonders of the Kremlin, we measured with less facility, being always interrupted by the sentinels, one of whom pointed his bayonet at us, and threatened to stab us if we persisted in our intention; yet by walking its length we found it about eighteen feet and a half, and its diameter may be guessed, because it will admit a man sitting upright within its mouth. Its lip, moreover, is ten inches thick. This gun is merely kept for ostentation and never used, notwithstanding the neglect it has experienced it remains in good order, without injury. It was cast in 1694. According to the *Voyage de Deux Français* Tom. II. p. 296, its weight is 2400 pouds, and its dimensions sixteen French feet in length, and four feet three inches in diameter, deducting sixteen inches for the thickness of the piece."—Clarke's *Travels*, 1800, Vol. I. p. 117.

He adds in a note :—

"In Eden's History of Travayles, as augmented by Willis, and printed by Jugge, in the black letter, at London in 1577, it is gathered out of Paulus Jovius, and proved, that they had the use of artillery in Moscow as early as the reign of Basil Ivanowitch (Wasilei Ivanowitch 1505–1533). 'Basilius dyd furthermore instytute a band of hargabusiers on horsebacke, and caused many great brasen peeces to be made by the workmanship of certayne Italians, and the same with thejr stokes and wheeles to be placed in the castle of Mosca.' "—Eden's *Hist.* p. 301.

Major-General de Novitzky has kindly furnished a description of the gun in the Russian language, from which he has extracted and translated the following particulars :—

"*On the fore part of the gun there is,* A likeness on horseback of the Tzar THEODORE IVANNOWITCH with the words 'by the Grace of God Tzar and Grand Duke Theodore Ivannowitch, Sovereign and Autocrat of all Great Russia.'

"*On the right-hand side the words,* 'By order of the Orthodox and Christ-loving Tzar and Grand Duke Theodore Ivannowitch, Sovereign and Autocrat of all Great Russia, during the life time of his Orthodox and Christ-loving Tzariza Grand Duchess Tzina."

"*On the left-hand side the words,* 'This gun has been cast in the most famous city of Moscow anno 7094 (A.D. 1586) in the third year of his reign. The gun was made by the gun-maker ANDREA ICHOCHOW.' "

The account proceeds to say :—

"This gun, the greatest of all the artillery pieces known down to this day, received among the common people the surname of Tzar Pooshka, either and most likely because of its unusual dimensions, or perhaps in consequence of the likeness of the Tzar being on its fore part."

There is one other question which must not be overlooked in connexion with cannon of bronze, viz. the composition of that indefinite alloy in each case. Bronze, like gold, is in a perpetual process of conversion from one form to another, the quantity of new metal bearing but a small proportion to the whole quantity in circulation; thus we need not speculate whence was derived the 7 or 8 tons of tin which entered into the composition of MALIK-I-MYDAN, for much of it may have left the mines of Borneo or Cornwall ages ago, but the study of these alloys throws light on the metallurgical knowledge of their day, and we discover with interest how often chance or skill guided the founders to the best or nearly the best proportions. The MALIK-I-MYDAN has been analyzed, but LT.-COLONEL MEADOWS TAYLOR, who has recorded the result, does not give his authority. The DHOOL DHANEE was analyzed by the Assay Master of the Mint, Calcutta, before it was broken up. The great gun of Muhammad II. and several others have been analyzed by MR ABEL, Chemist to the War Department, and that gentleman has kindly embodied the results in a memorandum subsequently read before the British Association at Norwich, with which I conclude this paper :—

MEMORANDUM *relative to the chemical composition of the Great Cannon of Muhammad II. recently presented to the British Government by the Sultan Abdul Aziz Khan.* (See "Chemical News," Sept. 4, 1868.)

"Specimens of the alloy composing this interesting cannon were detached for analysis from the mouldings or projecting rims which exist at either end of each part of the cannon.

"The metal was found to be more or less thickly coated with suboxide of copper, which had passed into carbonate here and there. In some parts, where the porosity of the metal had been considerable, the oxidation had proceeded to depths varying from 0·2 to 0·5 of an inch, and even upwards.

"The alloy was found to vary greatly in hardness, and most of the small specimens detached were porous and differed from each other considerably in colour.

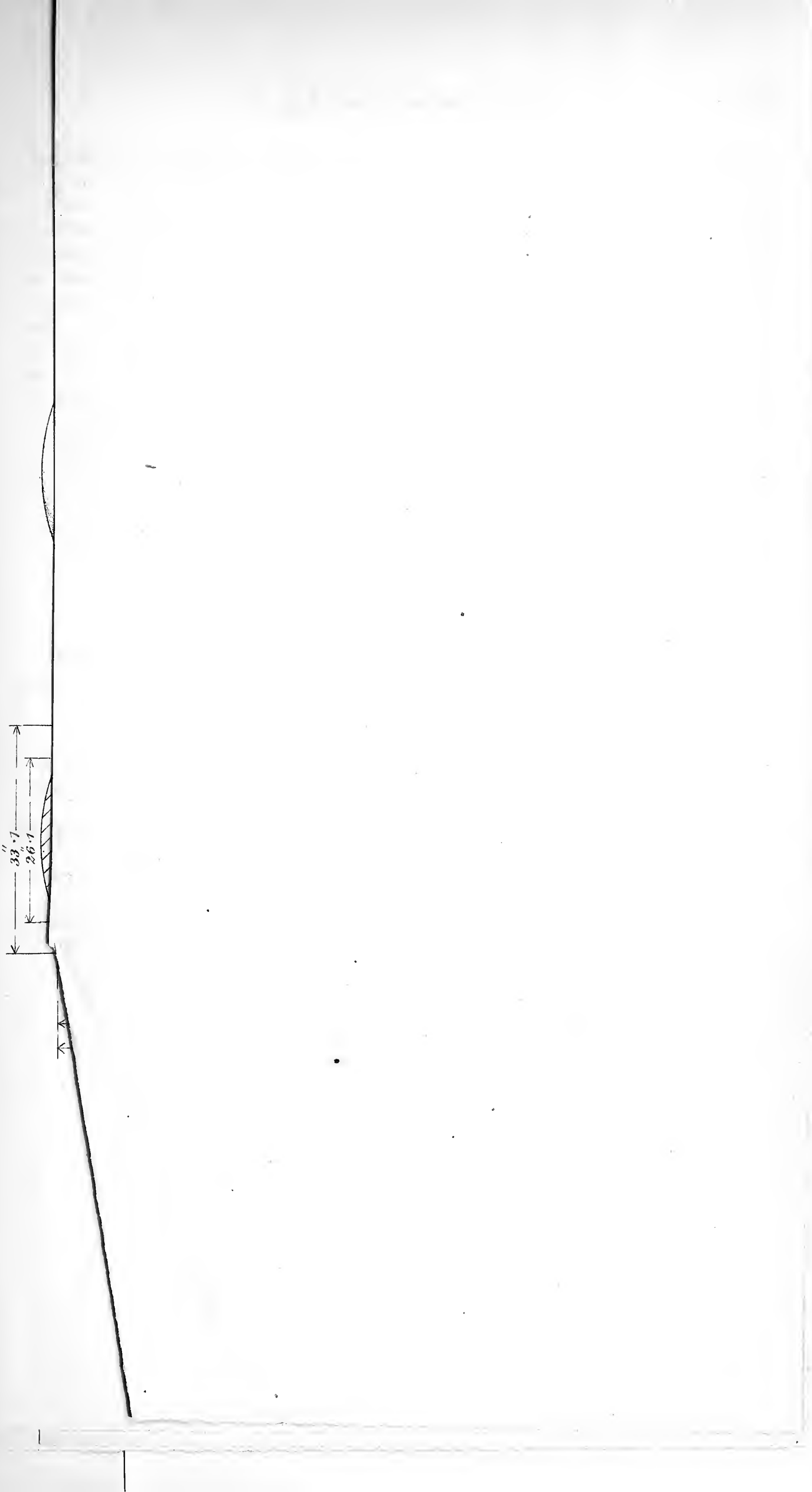
"Some presented the usual appearance of gun-metal of good quality (*e.g.* samples 1 and 4); in their immediate vicinity were found patches of white alloy (samples (1*a* and 2) rich in tin, such as are observed occasionally in bronze castings in which the mixture of metals has been imperfect, or which have been allowed to cool very slowly; again, other portions (samples 3*a* and 5) more nearly resembled pure copper in colour, and were comparatively very soft.

"The proportions of copper and tin in the several samples analyzed are as follows:—

a. "From the moulding at rear end of the breech-piece,—

	1*a*	1*b*	
Copper	92·00	89·58	per cent.
Tin	7·95	10·15	"

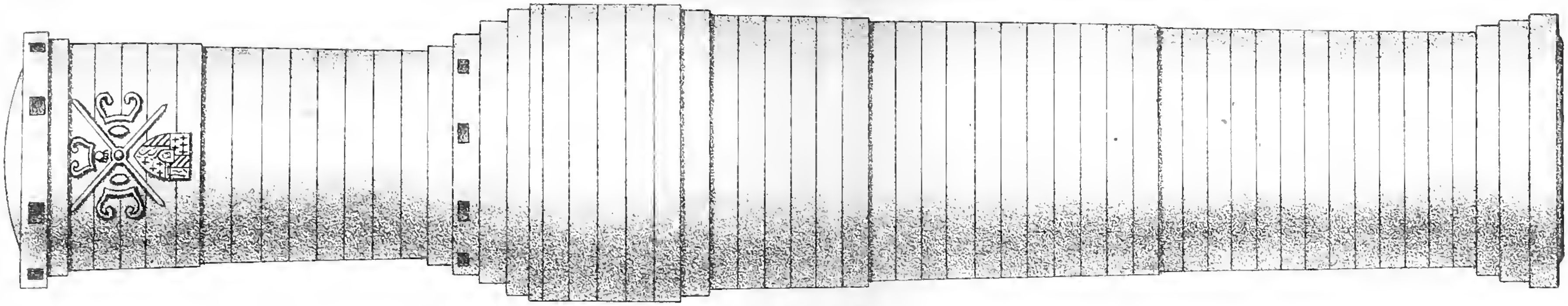
(in close proximity to No. 1*a*).


33·7"
26·1"

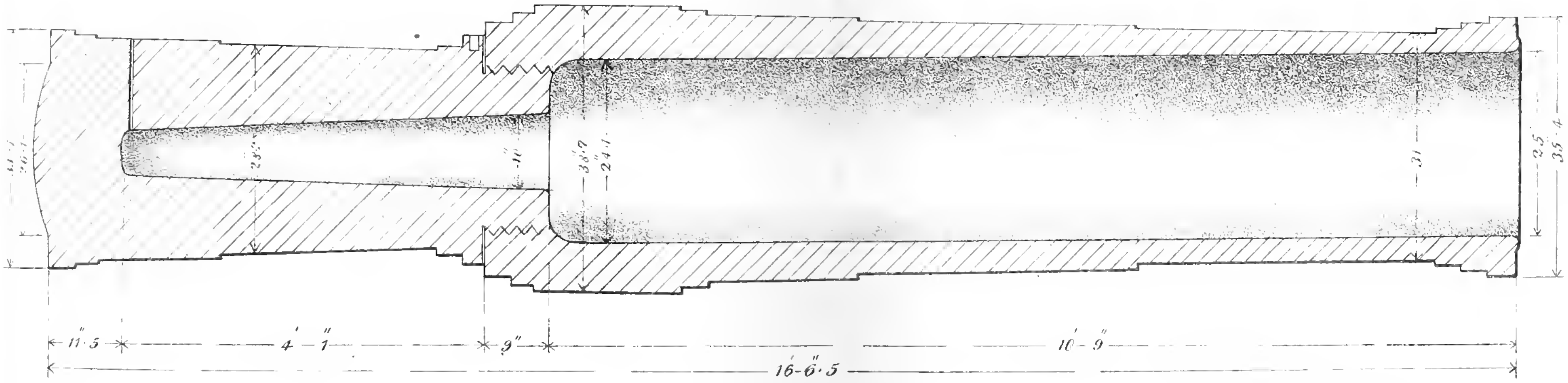
THE DULLE GRIETE

Wrought iron gun at Ghent, probable date A.D 1430
From measurements by Professor W. Pole F.R.S. September 1864.

Scale 1/24th



LONGITUDINAL SECTION.



Lithographed at the Royal Artillery Institution

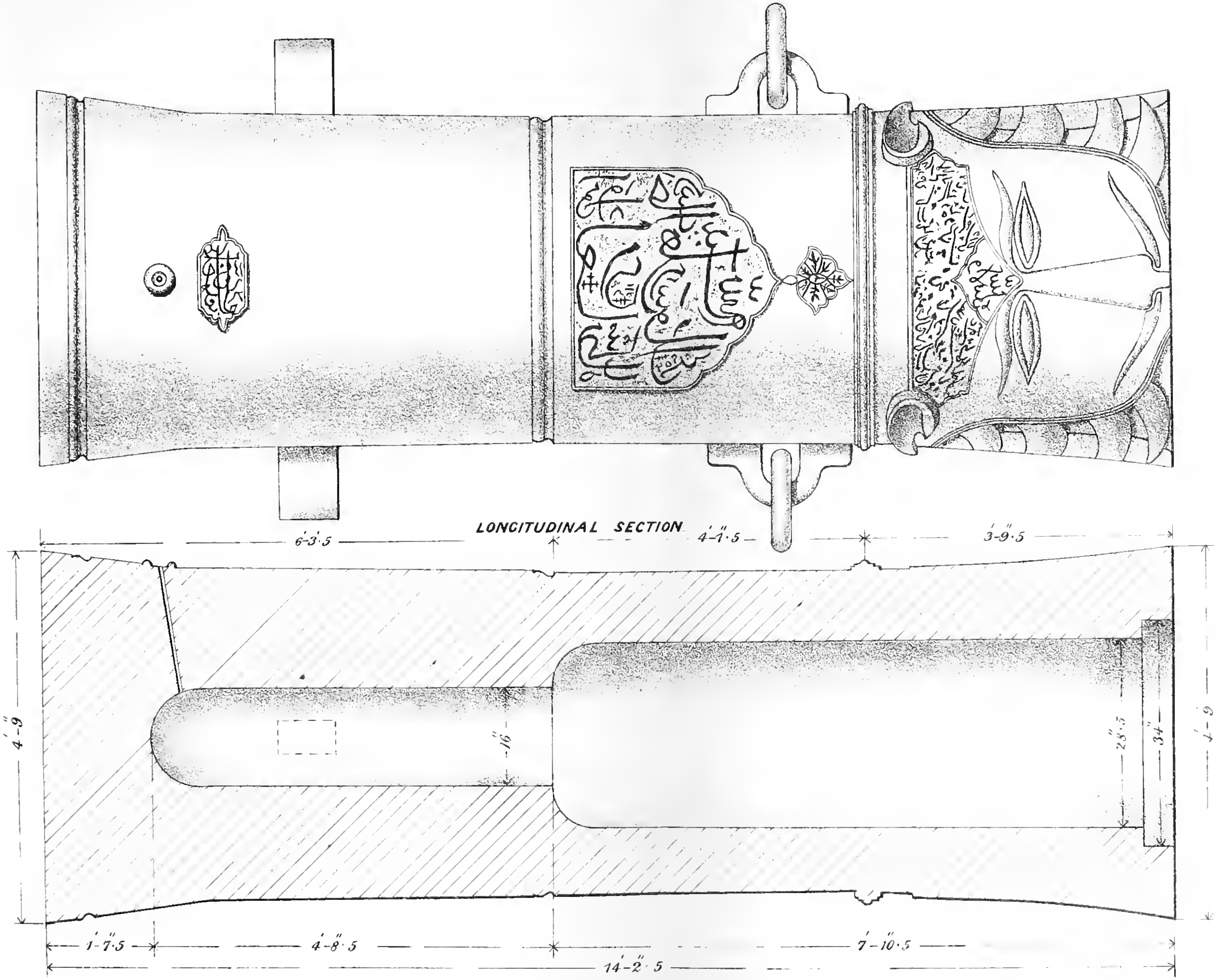
PL. III

GREAT GUN OF BEEJAPOOR.

THE MOOLK I MEIDAN OR MASTER OF THE FIELD.

(Cast in A.D. 1548.)

Scale $\frac{1}{24}^{th}$



LONGITUDINAL SECTION

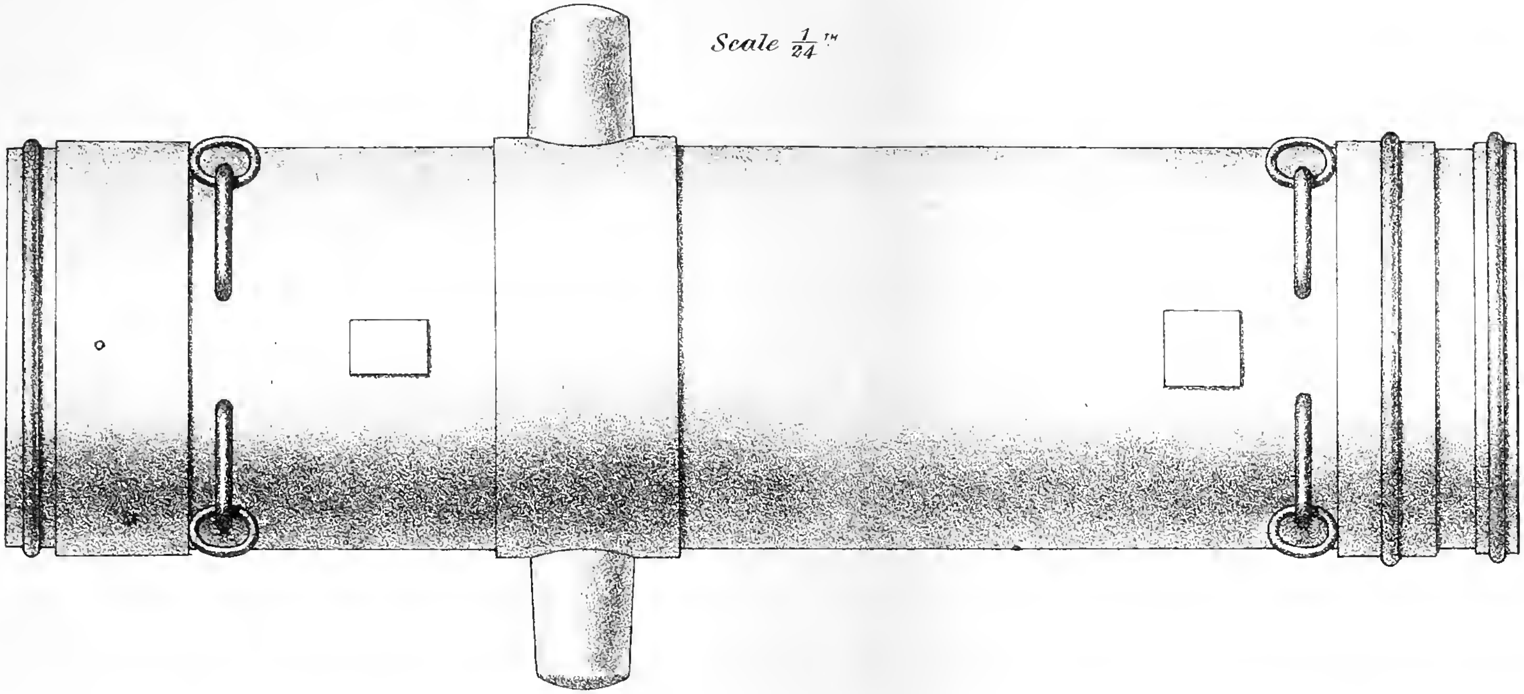
Lithographed at the Royal Artillery Institution

GREAT GUN OF AGRA.

DHOOL DHANEE

Cast A.D 1628 broken up and sold for the Metal 1832 From a drawing by
Captain J F Boileau Bengal Engineers 28 April 1832.

Scale $\frac{1}{24}^{TH}$



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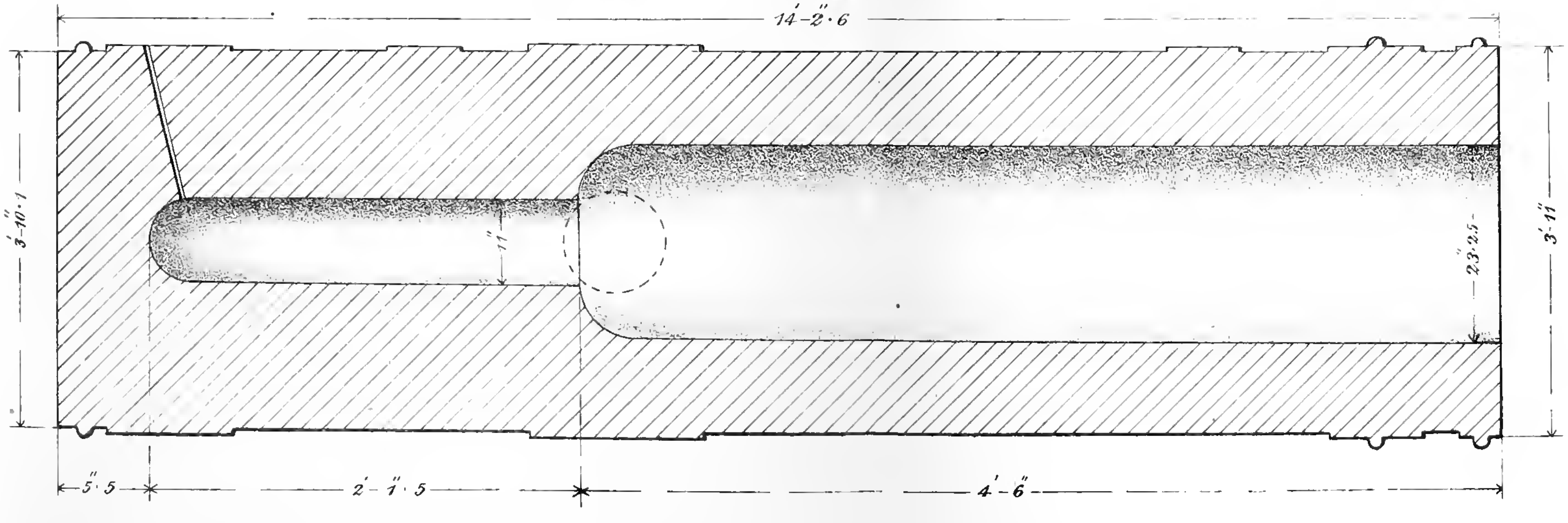
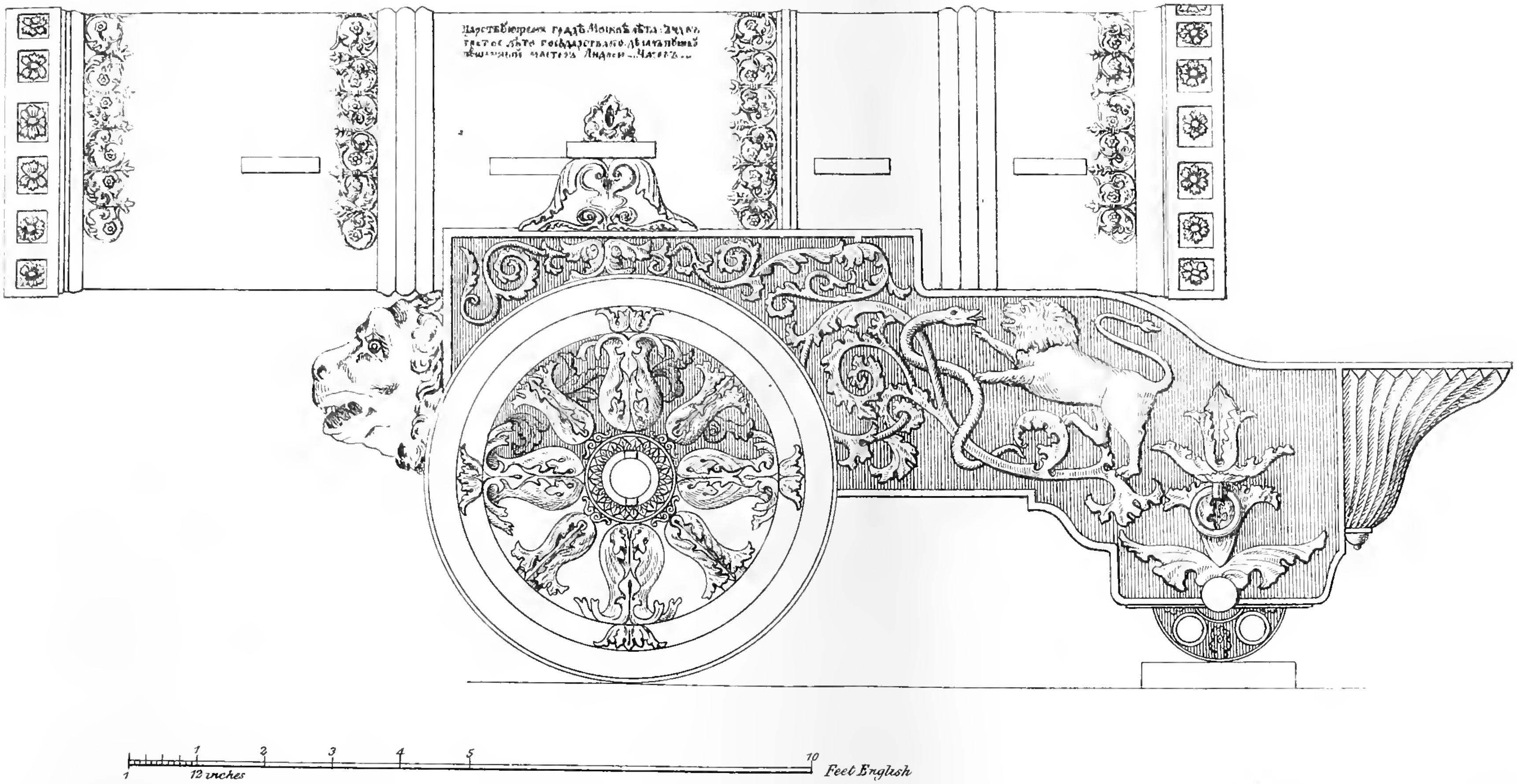


Lithographed at the Royal Artillery Institution

TZAR=POUSCHKA

THE GREAT GUN OF MOSCOW, CAST A. D 1586.

Diam of bore 36 inches Diam of chamber 19 inches
Length of bore 122 inches Length of chamber 70 inches
Total exterior lenght 210 inches Weight 38·15 tons.



Lithographed at the Royal Artillery Institution.

ANCIENT INSCRIPTIONS IN RELIEF.

On three Turkish Guns at the Dardanelles cast in
A.H. 928 or A.D. 1542.

سلطان سليمان بن
عمل مصطفى بن مراد

وفي وقت شاه عادل لا زال سنه ٩٢٨ فعلت المدافع القلاع
قال المورخ للمدفع الكبير هدم البيوت وقصر البقاع

ENGRAVED INSCRIPTIONS.

Of the Second degree	٢	درجه			
Diam.r of Powder chamber	قطرى خزينه	برمعه ٧	*7 inches*	٨٠ بعطه	*80 points*
Diam.r of Mouth of Gun	قطرى اغز	١٩	*19 „*	٠٠	*points*
Diam.r of Shot	قطرى كله	١٨	*18 „*	٥٠	*50 points*
Weight of Shot	وزنى كله	٢٢٠	*220 okes*	٠٠	
Weight of Powder charge	حقه باروت	١٦ ٠	*16 „*	٠٠	

Lithographed at the Royal Artillery Institution

b. "From the moulding at front end of the breech-piece,—

	2	3*a*	3*b*	
	Top of moulding.	Side of moulding.		
Copper............	90·57	93·70	94·22	per cent.
Tin	9·75	6·23	5·60	"

c. "From the moulding at the rear end of the chase,—

	No. 4.	
Copper	91·22	"
Tin	8·49	"

d. "From the moulding at the muzzle,—

	No. 5.	
Copper	95·20	"
Tin	5·71	"

"Samples 1 and 4 approach closely in composition to the best description of gun-metal of recent manufacture.

"Nos. 1*b* and 2, which are comparatively rich in tin, exhibited specks of white alloy interspersed through the mass.

"Nos. 3, 3*b*, and 5 contain higher proportions of copper than have been found in any other specimens of ancient gun-metal, the results of which have been published. Thus, the large Bhurtpoor gun at Woolwich, which was cast in 1677, contains from 60·5 to 86 per cent of copper in different parts of the gun; a large bronze gun also at Woolwich (one of four which were cast at Florence in 1750), contains 89 per cent of copper, and about 10 per cent of tin.

"The Malik-i-Mydan, or great gun of Beejapore, which was cast in 1648, is stated to contain only 80·42 per cent of copper, and 19·5 per cent of tin; and the Dhool Dhanee, or great gun of Agra, which was cast in 1628, contains (according to the analysis made by the Assay Master in Calcutta in 1832), 92·7 per cent of copper, and 7·3 per cent of tin near the muzzle, and 88·3 per cent. of copper to 11·7 per cent. of tin near the breech.

"It is interesting to note that in the seven specimens taken from the great gun of the Dardanelles, which have been analyzed, only traces of other metals than copper and tin have been discovered. Lead and iron were detected in minute quantities, and traces of antimony and arsenic were also discovered, but a careful examination of the specimens for gold, silver, and zinc, failed to furnish any indication of the presence of those metals."

(Signed) F. A. ABEL,

War Department Chemist.

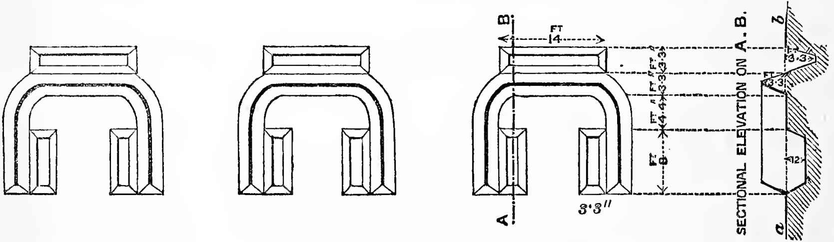
CHEMICAL DEPARTMENT,
Woolwich, Aug. 6, 1868.

INTRENCHMENT OF FIELD ARTILLERY.

BY LIEUTENANT R. WALKEY, R.A.

The method of intrenching Field Artillery as shewn in the plan below is that adopted by the French army at the camp Chalons, and as in future campaigns it is probable that intrenching will take place to a much greater extent than hitherto, it may be well to make known a means of obtaining cover quickly by throwing up a number of detached works.

The plan given is copied from a French drawing, and as all necessary dimensions are marked, only a few details of construction are added.



French system of Intrenching.

The battery being drawn up in line, a distance of (7) seven feet is marked out on either side of the muzzle of each gun, and a breadth of 3 feet 3 inches is measured to the front; on this rectangle of 14 feet by 3 feet 3 inches is built up the parapet, the earth for which is obtained from a ditch 3 feet 3 inches deep, and 3 feet 3 inches wide, dug in front.

From each extremity of this front face, 12 feet are measured off at right angles to the face, and at a distance of 4 feet from each angle formed by the face and flank a ditch 3 feet 3 inches wide and 2 feet deep is dug. The width (3 feet 3 inches) of each of these ditches is measured in towards the interior of the work and the earth from them is thrown outside, instead of inside as was the case with the front ditch.

Some of the earth from the front and flank ditches must be placed so as to form the parapet of the epaulments, and though this be done, since freshly dug earth occupies a greater space than that of the hole from which it is obtained, there will still be enough earth to give a parapet 3 feet high around the work.

Not more than seven men can conveniently dig at the same time, three being able to work in the front and two in each flank ditch, but other men can be well employed in revetting the parapet with sods and building up in places where required.

The Officers of the present long course at Shoeburyness intrenched two guns after this method and were a little over an hour completing each work; the soil however was especially unfavourable, the surface earth being extremely hard on account of the recent drought, whilst that below was very stiff clay.

Cover to a height of 3 feet was obtained, and from a distance of 600 yards the guns appeared much protected, and certainly were so from the fire of musketry. It was however generally remarked that the space in the interior of the work was too limited, for when the trail was much thrown over to either side, there was danger when the gun recoiled of one wheel running back into a flank ditch.

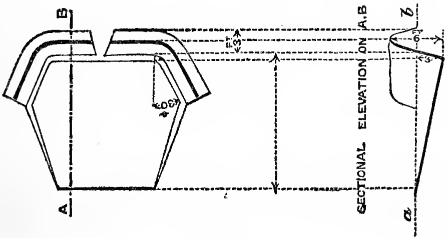
The commandant of the fortress of Kehl, General Baron de Weiler, to whom the Officers of the Royal Artillery at Shoeburyness are indebted for the tracing from which the plan shewn in this paper has been copied, stated, that in the intrenchments which he had seen constructed by the different continental armies, the flanks were generally made at an angle of 45° with the face instead of at right angles to it, and as for several reasons this method appeared preferable, other works so constructed were thrown up and finished in half an hour, which is the time that they are made in by the French soldiers.

An old gun mounted on a broken carriage was placed in each work, and dummies to represent gun detachments fixed around, three figures at each gun being left exposed, whilst the others were placed standing in the flank ditches.

Fire from four 12-pr. Armstrong field guns with segment shell and percussion fuzes was then opened from a distance of 1000 yards. Forty rounds were rapidly expended, and it was plain to the officer on range duty that the works would be quite untenable under such a severe fire. Upon examination it was found that nearly all the dummies left exposed were hit, whilst the guns were struck in many places, and the parapets of two of the works were much knocked about owing to shells having burst in them.

About the same effect was produced by forty rounds fired from the same guns at 800 yards range, common shell with time fuzes being used, but the parapets were not so much injured.

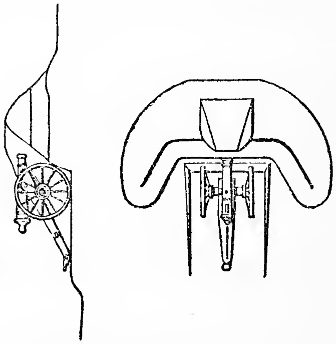
At the same time that the works referred to were being made, a party of non-commissioned officers intrenched a gun in a pit, which was made three feet deep in front with a gradual slope upwards to the rear. The earth from this pit was thrown up so as to form a parapet three feet high in front and on either flank, and lastly a small embrasure for the gun to fire through was cut in the front face.



Gun Pit.

Whilst this pit took no longer to make than the one of the detached works before described, it afforded greater and more efficient cover; greater inasmuch as the parapet was six feet high in front, and more efficient since three feet of this parapet were cut out of solid earth; indeed, after standing in a work of each kind, viz. a pit, and intrenchment constructed according to the French system, one could not for a moment hesitate to pronounce in favour of the pit as regards protection to the detachments and guns.

It must not be forgotten that in making this pit (which was rather bigger than is necessary) the men working were supplied with seven spades and seven picks, a greater number of tools than is carried by a subdivision of a battery. But a few days afterwards when Col. Michell, R.H.A., was with his Battery of Royal Horse Artillery at Shoeburyness, he ordered a serjeant and the six dismounted gunners of a detachment to intrench their gun, making use only of the tools carried by their subdivision, viz. two spades, two shovels, two picks, and he told them to take what advantage they could of a slight ridge running along the front of the battery. The party set to work, and by digging a recess, so to say, in the reverse side of the bank obtained excellent cover; the bottom of this recess was horizontal, the rear left quite open to facilitate limbering up, and it was completed in half an hour. The ground selected was of rather more than ordinary stiffness, and the tools were found to be sufficient as there was not room for more than four men to dig at the same time.



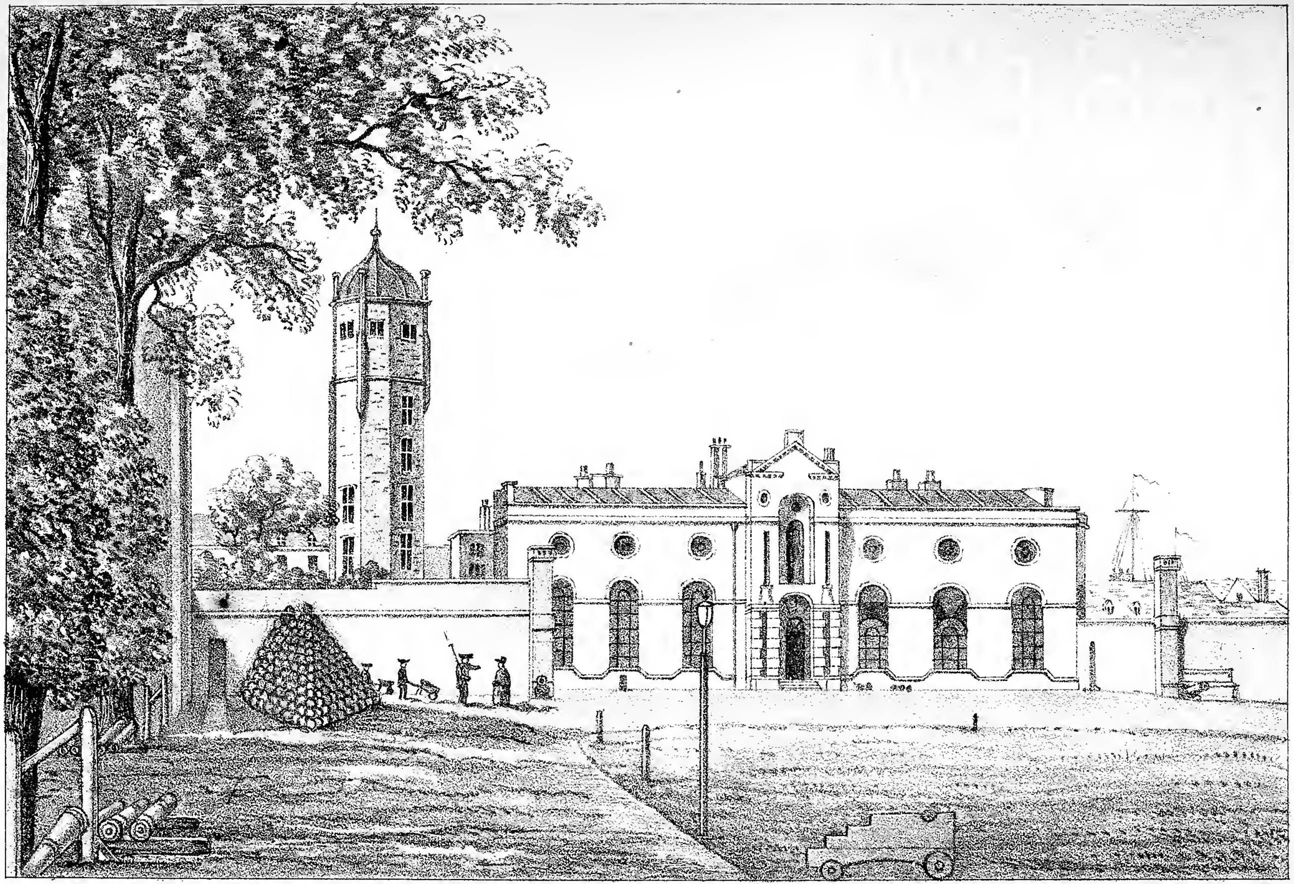
Gun Pit constructed by Colonel Michell's Battery, R.H.A.

This trial must be considered a fair one, for since only the intrenching tools always carried by a subdivision were used, and the position chosen was such as is generally sought for by artillery, it was made under no favourable circumstances, but carried out as it probably would be on active service.

Against making pits it is urged that in heavy rain they become pools of water; that when the gun recoils the trail and wheels of the carriage soon imbed themselves in soil soft owing to the surface earth having been removed; and that on account of the guns being nearly on a level with the ground any slight inequalities in front are not searched into by the fire.

On the other hand pits for field guns are not likely to be occupied for more than a few hours; whilst the guns are so light and handy that the objection as regards the soil being soft cannot be considered important: and a grazing fire, provided all the ground in front be commanded, is exactly what is wanted.

It is however not the intention of the writer to advocate any particular system of obtaining cover, so much as to bring to notice that continental armies are busy practising intrenching field artillery, and to point out that in the short space of thirty minutes, half a dozen men from a gun detachment can throw up around their gun a work, which if properly made, will afford them some shelter from the enemy's shells and greatly defend them from the fire of his riflemen.



Lithographed at the Royal Artillery Institution.

ROYAL MILITARY ACADEMY AND PRINCE RUPERT'S TOWER, WOOLWICH-WARREN.

The Tower was taken down August 1786.

HISTORICAL NOTES

ON

THE ROYAL ARSENAL AT WOOLWICH.

BY

LIEUTENANT G. E. GROVER, R.E., F.S.A.

As there exists no authentic record of the origin and growth of the Royal Arsenal at Woolwich, it is possible that the following notes (collected during a residence on the spot) may interest some of my brother officers who, when cadets, made acquaintance with the place, but had then no opportunity—and doubtless had then no inclination—to study its history.

It should be premised that a continuous or complete history of the establishment will not here be attempted; the limits of time, space, and ability, forbid such an enterprise. This paper can claim to be little more than a compilation of notes, whose want of originality is almost necessitated by the very nature of its subject.

The writer's great ambition is to disprove the story—which has gained such general credence—that the Royal Arsenal was founded but a century and a half ago, and then at the instigation of a foreigner.

As a manufacturing establishment, it can boast perhaps no greater antiquity than 150 years, but, as a military post and a store *depôt*, it existed much earlier. It would be rash to assert that, on this very site, there stood an ordnance establishment in Queen Elizabeth's reign; yet there did exist an ordnance armoury at Woolwich in the commencement of the seventeenth century, and "Remaines of the Armour of the Tower and Woolwich, Anno 1603," set forth* that there were "at Woolwich, as in the former Remaine taken, iiii Backes & Brests for Almayne Corsletts (besides 1 od backe), lxxv Collers with Bombards, xlviii Burgonetts and huskins, cccxxxiii Murrions blacke, & xii Burgonets old and nothing worth."†

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* "Parochial History of Enstone," by the Rev. J. Jordan.

† The "*Backes & Brests* for Almayne Corsletts" were the plastrons and carapuces for suits of armour put together with Almayne, or German, rivets—worn by pikemen who, from the use of such harness, acquired the title of "Corslets." *Bombards* were the padded breeches worn by the military at the end of the 16th, and commencement of the 17th century. *Burgonetts* were the close-fitting helmets invented in Burgundy in the 15th century, and employed in England as late as the reign of Charles I.

The Royal Arsenal was not so named till the year 1805. Before that date it was styled the "Tower Place" or "King's Warren." There exists no record whatever of the time, or manner, in which the Board of Ordnance acquired this property, comprising, as shown on the accompanying plans, the forty-two acres at the west end of the present Royal Arsenal. I am of opinion, however, that it was first taken in June, 1667, as a site for the 60-gun battery thrown up to protect Woolwich against the invading Dutch fleet; and my reasons are as follows. Amongst the State papers preserved in the Record Office is a letter, from the King to Prince Rupert, dated the 13th June, 1667, and setting forth that "having ordered works and batteries to be raised in or near Woolwich, for better security of the river against attempts of the enemy, he wishes him to go thither and direct the same; also charging persons of all ranks to obey his orders therein." A letter written seven days later from Whitehall, by Henry Muddiman to Sir George Cooke at Wheatley, Doncaster, mentions that there had been built a platform* at Woolwich with 60 pieces of ordnance. Now, the Royal Military Repository at Woolwich possesses the oldest known plan of the Warren—bearing the date 1701 and the signature of the celebrated general Albert Borgard—and this plan shows a parapet, along the river wall, 13 feet thick and pierced with 40 embrasures at central intervals of 18 feet, there being room for at least 20 more guns on the parapet if required. It also shows, in rear of the parapet, "Prince Rupert's Walk;" and, in rear of that, a wet ditch surrounding what appears to have originally been a triangular demi-bastioned work, such as were common in England towards the middle of the seventeenth century. Moreover, the old tower which formerly stood near the present Royal Laboratory pattern-room was always known, and shown on old plans, as "Prince Rupert's Tower." I think that the foregoing particulars tend to prove that the Warren was the site of the batteries thrown up at Woolwich in 1667.† That the Warren was not Ordnance property prior to that year, I conclude from the non-existence, in the Record Office, of any documents referring to it and bearing earlier date; though there have been preserved therein innumerable orders and letters relating to the Woolwich dockyard, and its rope yard, and to the several ordnance stations in England. Amongst them, for example, is the correspondence between the Office of Ordnance and the Admiralty, in October 1667, for the charge of the timber provided to the former by the latter department for "the late batteries at Woolwich."

The accompanying Plan No. 1, reduced from a drawing of the Warren dated 1717, is identical with General Borgard's old plan in the positions and designations of the buildings, except that a "Greenwich Barne" seems to have in 1701 occupied the site on which the Brass Gun Foundry was afterwards built in the year 1717. In the Ordnance "Journall Bookes," now stored in the Tower of London, I have found the authority dated the 19th December, 1695, for taking down this "Barne" in the Greenwich Tilt Yard, and re-erecting it at Woolwich.

Amongst these Ordnance records in the Tower, I have also found a manuscript dated 9° July 1664, "Estimate of Reparatо̃ns y^{t} must of

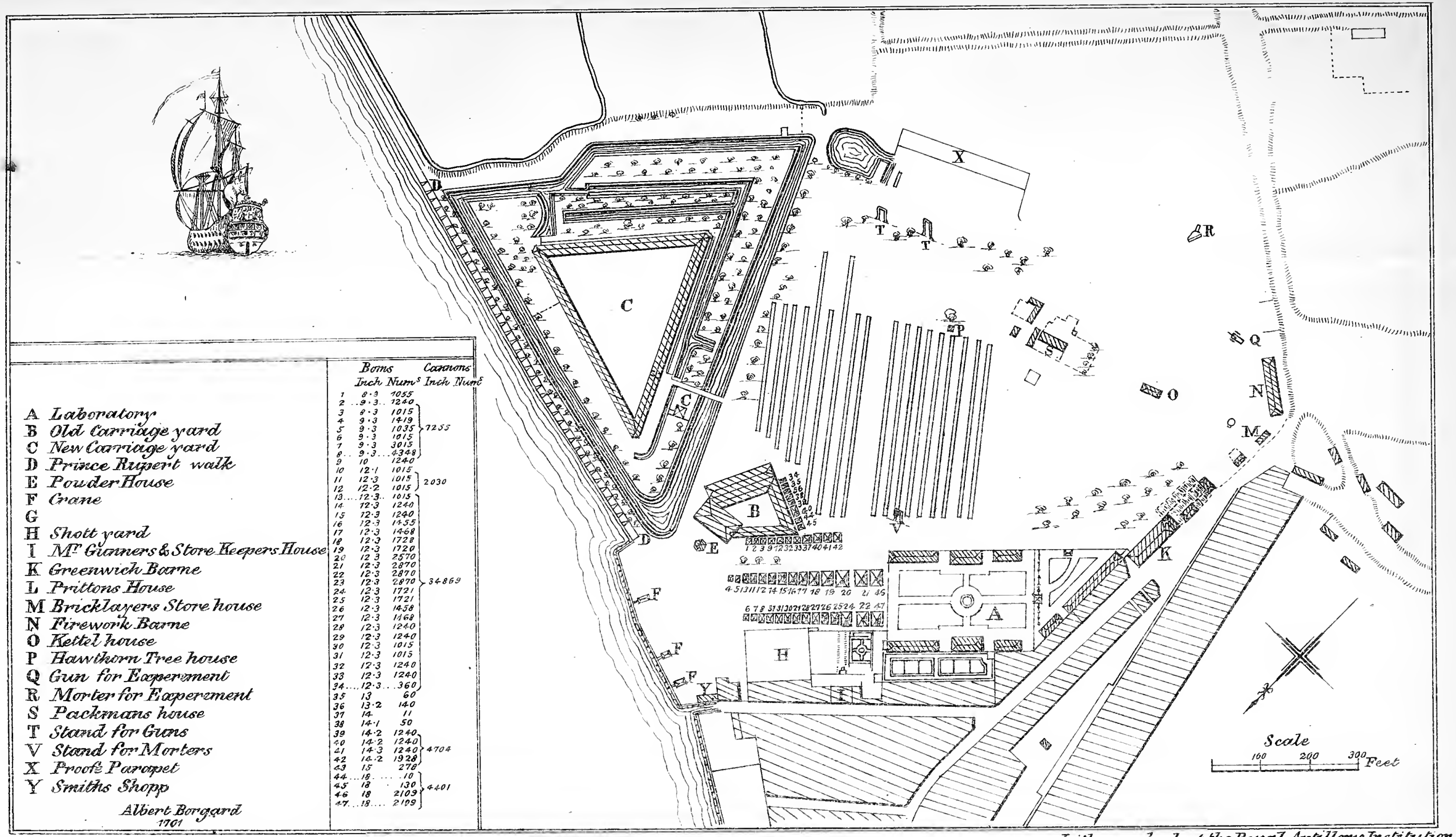
---

* *i.e.* rampart.

† Some contemporary accounts of these batteries are related in p. 242.

THE WOOLWICH WARREN IN 1701.

(Reduced from a plan in the Royal Military Repository. Woolwich.)



	Boms		Cannons
	Inch	Nums	Inch Nums
1	8·3	1055	
2	9·3	1240	
3	8·3	1015	
4	9·3	1419	
5	9·3	1035	7255
6	9·3	1015	
7	9·3	3015	
8	9·3	4348	
9	10	1240	
10	12·1	1015	
11	12·3	1015	2030
12	12·2	1015	
13	12·3	1015	
14	12·3	1240	
15	12·3	1240	
16	12·3	1455	
17	12·3	1468	
18	12·3	1728	
19	12·3	1720	
20	12 3	2570	
21	12·3	2870	
22	12·3	2870	
23	12·3	2870	34869
24	12·3	1721	
25	12·3	1721	
26	12·3	1458	
27	12·3	1168	
28	12·3	1240	
29	12·3	1240	
30	12·3	1015	
31	12·3	1015	
32	12·3	1240	
33	12·3	1240	
34	12·3	360	
35	13	60	
36	13·2	140	
37	14	11	
38	14·1	50	
39	14·2	1240	
40	14·2	1240	4704
41	14·3	1240	
42	14·2	1928	
43	15	278	
44	18	10	
45	18	130	4401
46	18	2109	
47	18	2109	

Lithographed at the Royal Artillery Institution

necessity bee p̄sently done to make y^{e} Stoare-houses wind and water tite for y^{e} keeping dry of y^{e} Powder Match and other provisions, and to keepe y^{e} said store-houses from falling downe and utter Ruin," of which estimate one item provides for "floaring a Stoarehouse att Woolwich to keepe shipp Carriages dry." It is probable that this was the old shed referred to in the following orders of the 5th October, 1680. "That y^{e} Sheds at Woolw^{ch} along y^{e} Proofe house and y^{e} Shedds for Carriages there be forthwth Repaired;" and 14th November, 1682, "That y^{e} Officers of y^{e} Board do Contract with all convenient speed wth Artificers at y^{e} reasonablest rates for his Maj^{ties} Service for building of a new Shedd 18 fo^{t} broad and 100 fo^{t} long at Woolw^{ch} for lodging of Ship Carriages in y^{e} place where y^{e} old one is fallen down, according to y^{e} Survey thereof this day dd to y^{e} Board by S^{r}. Ber. de Gom̄e dated 13 Nov. 1682." (Sir Bernard de Gomme was then Surveyor to the Ordnance, and His Majesty's Chief Engineer).

It appears, from General Borgard's above-mentioned plan, that in the year 1701 there stood in the Woolwich Warren a "New Carriage Yard" and an "Old Carriage Yard;" which latter contained a south building 100 feet long and 18 feet wide, agreeing with the dimensions particularized in the foregoing Board's Order.

Not storage only, but workmanship also, was at that time found for gun carriages at Woolwich. Early in 1683, Mr Peach the storekeeper broke up 89 condemned carriages and took out all their iron work.

In 1668 it was ordered that "all y^{e} Gunns Carriages and Stores now att Deptford be removed from thence to Woolw^{ch}, and from henceforth new Ordnance and Carr^{s} be layd there."

The laboratory establishment was apparently moved from Greenwich to Woolwich in 1695. On the 3rd of December in that year, a warrant was issued "to William Edge to fetch Gravell, and raise and Levell the Ground at the new Labouratory att Woolwich, takeing the Surveyor's direction therein to be according to agreement made with him by Mr Boulter."

On the 23rd January 1696 Mr Boulter was desired "to goe to Woolwich tomorrow to give direc̄ons for fitting up the Laboratory." Lt.-General Borgard records, in his autobiography,* that in 1718, "I likewise laid before the Board the Ill state of the Laboratory, which the Board order'd me to put in some better order and to be at as little expense as possible, which I did accordingly."

Saltpetre stores are mentioned in the Ordnance "Journall Bookes" as existing in the Minories in 1663, and at Woolwich in 1680, when they were in charge of a "storekeeper of saltpetre." But in the Record Office there lies a petition dated 1662, from one Owen Hurst "for the charge of the saltpetre house at Woolwich, and the refining thereof, not yet committed to the special charge of any person."

In February 1681 Sir William Warren was invited "to contract for the making of Two Butts at Woolwich for the Tryall of a fire shott prepairing of Cap^{t}. Leake Master Gunner of England," the estimates for which butts had been previously submitted to, and approved by, Sir Bernard de Gomme.

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* In the Royal Artillery Library at Woolwich.

In December 1682 "y^{e} number of 1000 cañon 10000 D. Cañon Round Shot were taken out of y^{e} unserviceable Byns upon Tower Wharfe, each side Traitor's Gate, and sent down to Woolw^{ch}." Two or three years later, a regular "Shott Yard" seems to have been established, as shown in the accompanying Plan No. 1.

It was ordered, 4 October 1684, that "A Wooden Butt shall be Built at Woolw^{ch} according to Cap^{t}. Leake's direc̄ons y^{e} Ma^{r} Gun^{r}. of England," who, at this time, occupied a house in the Woolwich Tower Place. In 1681, the Board of Ordnance acknowledged its liability to keep in a proper state of repair the bank of the river Thames forming the water boundary of the Tower Place at Woolwich.

Before the year 1716 all ordnance, for the military and naval services, was obtained from private manufacturers; but proved, before receipt by the Board of Ordnance, at the Government proof grounds. A memorandum dated "y^{e} 3 ffeb. 1662," in the old Tower records, mentions "a building in the Artillery Garden late y^{e} City Armory, adjoining which are y^{e} old proofe house and y^{e} Butt." And in July 1663, it was ordered "that certain doe forthwith build a shedd in y^{e} old Artillery Ground by y^{e} proofe house." Mr Pepys mentions, in his diary for the 20th April, 1669, "the old Artillery Ground near the Spitalfields, where I never was before, but now, by Captain Dean's invitation did go to see his new gun tryed, this being the place where the officers of the Ordnance do try all their great guns." The old Artillery Garden or Ground here mentioned extended between the Devonshire and Spital squares, and the City armoury above named was built therein by James I. in the year 1622. Stow's "Survey of the Cities of London and Westminster in 1598," chronicles that "in Moorfields is the *New Artillery* Ground; so called, in distinction from another Artillery Garden,* near *St Mary Spital,* where formerly the Artillery Company exercised. Who, about the latter end of King *James I.* his Reign, were determined to move thence; and to hold their Trainings and Practice of Arms here; being the third great Field from *Moorgate,* next to the six Windmills. Which Field *Mr Leat,* one of the Twenty Captains, with great pains, was divers years a preparing to that purpose." Stow also mentions the "Artillery Yard, whereunto the gunners of the Tower do weekly repair, namely, every Thursday; and there, levelling certain brass pieces of great artillery against a butt of earth made for that purpose, they discharge them for their exercise."

The guns were stored, after proof, at the Tower and Woolwich. In the Record Office there is a warrant, dated 31st July 1663, "to Sir William Compton, master of ordnance, to order delivery to George Browne, gunfounder, of certain defective brass guns in the Tower and at Woolwich, that they may be recast towards furnishing the new frigate lately ordered." In the Ordnance journal books is a similar order, dated October 1663, "for new casting all old and unusefull ordnance in y^{e} Tower and Woolwich." There is likewise mention, on the 16th April 1663, of "the

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* Burton in his "Anatomy of Melancholy," published in 1660, speaks of the following pastimes as common to both town and country, namely "bull-baitings and bear-baitings, in which our countrymen and citizens greatly delight, and frequently use; dancers on ropes, jugglers, comedies, tragedies, *artillery gardens,* and cock-fighting."

Gunwharfe at Woolwich," and 8th May 1664, "That Mr Scott take care to repair y^{e} Crane at Woolwich and y^{e} Gate at y^{e} Wharfe." The Admiralty seems to have borne part of the expense of maintaining this gun-yard wharf, for Mr William Bodham, writing to Mr Samuel Pepys, from the Woolwich Rope Yard, 6th May, 1665, having ventilated, as much as possible, Edw. Rundell's estimates, can but pronounce him a prevaricating knave, and admires the audacious impudence of a bold mechanic who dares affront his superiors with such a piece of plain derision. He encloses the estimates by Edw. Rundell for a gallery from the old hemp loft to the street; total, £15. 1s. for repairing 38 feet of wharfing in the gun yard at Woolwich; total, £18. 2s. 4d. for altering and raising the shed at Woolwich ropeyard, £25. 18s. Also enlarged estimates for the same works, the prices being £27. 5s., £22. 16. 3d., and £23. 11s. 4d.

The proof of ordnance was transferred from Moorfields to Woolwich somewhere between the years 1665 and 1680, when Major Mathew Bayly was "y^{e} proofe master," and George Brown, Esq. was "his Majesty's founder of brass and iron ordnance." Private founders were occasionally allowed to prove their guns in the Woolwich Tower Place, at their own expense.

In 1684 Mr Western had a foundry at Moorfields (in the present City Road, near Finsbury Square) where he cast brass guns and mortars for the Ordnance: and, in 1695, Mr Fincher is recorded to have had "many considerable Contracts with this Office for Casting Iron Ordnance, Granadoe Shells, and Round Shott." A return was drawn up, in that year, "of what unserviceable Morter peices &c. there are at the Tower or Woolwich to be recast, that Direc̃ons may be given for delivering what shall be necessary thereof to the Founders." In 1704 Mr Mathew Bagley took the Moorfields foundry and, for twelve years, cast guns and mortars out of metal supplied for the purpose by the Board of Ordnance. An explosion which occurred at this foundry* in 1716 brought about the establishment of a government brass foundry in the Woolwich Tower Place where, according to the foregoing notes, there already existed the germs of the three great manufacturing departments of the present Royal Arsenal—the Royal Carriage Department, the Royal Laboratory, and Royal Gun Factories. The following are the particulars of an event so important in the annals of the Royal Arsenal.

After the peace of Utrecht in 1713, the guns captured from the French by Marlborough were placed outside the Moorfields foundry upon Windmill Hill. It was afterwards determined to utilize the metal by re-casting it in the form of English ordnance; and, on the appointed day—Thursday the 10th May 1716—a large number of spectators attracted by the interest felt in the trophies, and in the manufacture of large ordnance, attended at the foundry to witness the operation. The *Mercurius Politicus* of the 18th May states, "Several Gentlemen were invited to see the Metal run, which being a very great and curious Piece of Art, a great many Persons of Quality came to see it, and some General Officers of the Army among the rest; but whether it was some unusual hinderance in the Work, or their better Fate

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* The site of this foundry was afterwards occupied by the famous "Tabernacle" of the Messrs Whitfield and Wesley.

that occasioned the Metal to be longer preparing than usual, we know not, but be that as it will, the Gentlemen waiting till past Ten a Clock, went all or most of them away. About 11 at Night the Metal being ready, was let go . . . . the burning Metal no sooner sunk down to the Bottom of the Mould, but with a Noise and Force equal to that of Gunpowder, it came pouring up again, blowing like the Mouth of a *Vulcano* or a little *Vesuvius*. There was in the place about 20 Men, as well Workmen as Spectators, 17 of whom were so burnt that nothing more horrible can be thought of, neither can Words describe their Misery. About 9 of the 17 are already Dead, the other 8 are yet living, but in such a condition that the Surgeons say they have very small hopes of above 2 of them." In this explosion Mr Hall, clerk of the ordnance, was killed; several other clerks were wounded; Lt.-General Borgard, and Mr George Harrison (superintendent of the Foundries), were burnt; the master founder, Bagley, and his son, lost their lives. A bronze gun about 11 ft. long, spoiled in the cast, is now exhibited in the Rotunda at Woolwich, as the very gun which caused this disastrous explosion. The *Flying Post* of the 12th May 1716, says, "'Tis generally agreed that this sad Accident was owing to the Dampness of the Mould," and the *Weekly Journal* of the same date attributes the explosion to "the Workmen casting some Brass Guns in wet Molds."

The autobiographical memoir of Lt.-General Albert Borgard, in the Royal Artillery Library at Woolwich, contains the following account of this accident. "1716. On our arrivall at London I was order'd by the Board of Ordnance to lay before them Tables and Draughts of all Natures of Brass & Iron Cannon, Mortars, &c., which was done accordingly & approved of. After the said Draughts 2 Twenty Four Pounder Brass Cannon were order'd to be cast by Mr Bagley in his Foundry at Windmill Hill, at the Casting of which I was order'd to be present. In the Founding, the Mettall of one of the Guns blowed into the Air, burnt many of the Spectators of which Seventeen dy'd out of 25 Persons & myself received 4 wounds."

The following extract from the Tower records shows the result of this accident:—

"*Martis* 19° *die Junij*, 1716. It having for many yeares been the Opinion of the most experienced Officers that the Government should have a Brass Foundery of their own, and whereas Mr Bagley's Foundery is the only own for Casting Brass Ordnance & lyable to dangerous Accidents w^{ch} cant be prevented. It is therefore order'd that a Proposal and Estimate be made for Building a Royal Brass Foundery at His Majesty's Tower Place at Woolwich, & the Charge thereof Defrayed out of the £5000 given this Year by Parliament for recasting Brass Ordn^{ce} & y^{t} no time be lost herein, inasmuch as there are but 2 12-Pounders, and not 1 18 or 24-Pounder for Land Service. A Letter to Mr Henry Lidgbird to attend the Survey^{r} Gen^{l} the 20th about providing Bricks for the Royal Brass Foundry at Woolwich."

So promptly did action follow this decision that, but two months afterwards, the sum of £300 was paid for bricklayers' work upon the New Brass Foundry at Woolwich, and on the 10th July, 1716, the following advertisement appeared in the *London Gazette*:—

"Whereas a Brass Foundery is now building at Woolwich for his Majesty's Service, all Founders as are desirous to cast Brass Ordnance are to give in their Proposals forthwith, upon such Terms as are regulated by the Principal Officers of His Majesty's Ordnance, which may be seen at their Office in the Tower."

A month later, it was ordered that, if the results of enquiry proved satisfactory, Mr Andrew Schalch should "be employed in Building the Furnaces, and providing of the Necessary Utensills for the Royal Foundry at Woolwich at £5 a Day, untill Everything is provided and his performances approved."

It is then recorded:—

"*Veneris* 5° *die Octobris*, 1716. The Board having rec^{d}. a Lre. from Mr Leathes, his Majesty's Minister at Brussells, giving an acco^{t}. that Mr Andrew Schalk (*sic*) bears a good Character at Doway and was an able Founder. Ord^{d}. That the said Mr Schalk be employed in the Royal Foundry at Woolwich at £5 per diem from the 20th of Sep^{r}. last."

The foregoing particulars have been stated with a minuteness greater than their subject may seem to demand, because they tend to disprove the popular tradition that to Mr Andrew Schalch belongs the credit of selecting the site of, and virtually founding, the Royal Arsenal at Woolwich.

The following is the generally received, but erroneous, account of the events which are said to have resulted in the establishment of a Government Foundry at Woolwich, as related in all pamphlets, encyclopædiæ, guide books, and periodicals (even so respectable an authority as the *Quarterly Review*), which profess to treat on the Arsenal's history.* Andrew Schalch, a native of Schaffhausen in Switzerland, happened in the year 1716 to be travelling in England, as a journeyman founder, according to the laws of his canton. Attending at the Moorfields foundry on the 10th of May to witness the great castings of ordnance, he noticed a dampness of the moulds and, foreseeing that the steam which must be generated by their contact with molten metal would cause an explosion, warned Colonel Armstrong (then Surveyor to the Ordnance) to retire from the building with all whom he could persuade to accompany him. As Schalch predicted, an explosion took place, and a few days afterwards an advertisement appeared in the papers inviting the young foreigner—who, addressing Colonel Armstrong in French at Moorfields, had given him such timely warning—to call at the Tower, where he would hear of something to his advantage. Schalch called accordingly and was informed (after giving proofs of his ability and experience in the art of casting metals) that the Government had decided to move their cannon foundry from London, and entrusted him with the important commission of selecting a site for the new buildings. After examining all the eligible spots within a reasonable distance of the metropolis, Schalch (as the story goes) recommended the "Rabbit Warren," or "Tower Place," at Woolwich, as fulfilling all the required conditions of a site for the projected foundry. Being close to the river, it was conveniently situated for the purposes of transport; from its inland position, it was unexposed to

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* The earliest authority for this error which I have been able to find is Joseph Moser's "Vestiges," No. IV. dated October 1802, in the British Museum.

attack; it was only 12 miles distant from the seat of government; and it was in the immediate neighbourhood of good loam for the moulds.

Such is the story. I will not dwell upon its internal signs of improbability, but will merely assert (as the result of much careful research) that no such advertisement as it describes is to be found in any newspaper of the period, and that no allusion to the alleged circumstances is to be found in any contemporaneous journal or Minute Book of the Board of Ordnance. The advertisement and minutes which are really to be found I have already quoted *in extenso.*

Andrew Schalch served England well: for sixty years he was master founder at Woolwich.* But, though much honour is his due, there cannot be ascribed to his memory the credit of having founded the Royal Arsenal at Woolwich. The authors of this long-lived error seem most strangely to have thought a chance origin as probable as the advice of the public officials whose duty and privilege it was to observe the want, and suggest the founding, of such an important establishment.

The Brass Foundry and Dial Square buildings, in the Woolwich Arsenal, are said to have been designed by Sir John Vanbrugh (the celebrated architect of Blenheim House, Castle Howard, &c.). The former of these appears, from old plans, to have been completed in the year 1717. It is well described in the *Quarterly Review* for January 1858, "with a stately solemnity which marked the conceptions of its builder, Vanbrugh, stands the picturesque gun factory, with its high-pitched roof, red brickwork, and carved porch, looking like a fine old gentleman amid the factory ranges which, within these few years, have sprung up around. It is impossible to contemplate this building without respect, for forth from its portals have issued that victorious ordnance which, since the days of George II., has swept the battle grounds of the old and new worlds."

To Sir John Vanbrugh's pen are attributed three curious old plans to be seen in the King's Library at the British Museum, thus entitled:— "*Plan* of the *Foundary* buildt at *Woolwich* anno. 1715" (*sic*). "Part of the *Great Pile* of *Building* designed at the Tower Place at Woolwich, July the 9th 1717," (showing the south portion of the Dial Square) and "Front of the Gate next the River Thames for the Ship Carriage House, designed at the Tower Place at Woolwich instead of A markt 1717." It is recorded in the Board of Ordnance Minutes "Martis 24° die Julij 1716, That a letter be sent to Mr Wm. Meade to make out estimates for Building the Magazine at Tilbury Fort, the Foundery at Woolwich, & making two Wharfs over the Moat near the new Carriage Yard at do., Mr Ogborne applying for imprests for those Services."

To describe *seriatim* the changes which have occurred in the Royal Arsenal since the year 1717 would be too lengthy, too thankless, a task. Suffice it to say that, whereas the original Tower Place consisted of but 42 acres (and its extent so remained for 60 years), the present Royal Arsenal

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* He died, æt. 84, at Charlton in 1776. His two daughters married Colonels Belford and Williamson, of the Royal Artillery, and five of his descendants served in the same regiment. Some of Schalch's guns, cast in 1742, were raised from the wreck of the "Royal George" at Spithead in 1840.

covers 333 acres, in addition to the areas occupied by its two detached magazine establishments. And, whereas a local pamphlet entitled "Reasons for rebuilding Woolwich Church, 1718," sets forth that "There is near 1000 Families belonging to the *Navy Dock Yard* and *Rope Yard,* 200 Families belonging to the *Ordnance Service,* and about 100 Independant of either, which after the rate of 5 to each Family is 6500, and the said old small church cannot (at most) contain above 600 People . . . . . . And the Parish is very Populus and dayly increasing," the populations of Woolwich and Plumstead parishes are now 42,000 and 33,000 respectively. Mr Lysons* narrates that, in 1796, the number of artificers and labourers (exclusive of convicts) employed in the various departments of the Woolwich Warren was about 1500, including 300 boys; and that the making of canvas bags for the use of the Warren furnished employment for a great number of poor women in the town.

I propose now to glean together a few known particulars concerning the very earliest history of the Royal Arsenal's site.

Traces of a Roman occupation were here discovered in 1853, when some Roman pottery was dug up, and presented by the Board of Ordnance to the museum of the Royal Artillery Institution. Again, in 1856, some excavations for the foundation of a boring mill in the Dial Square brought to light a very graceful funeral urn and some more fragments of pottery, which are now deposited in the same museum at Woolwich. It will be remembered that the great Roman road, known as "Watling Street," passes (between London and Rochester) over Shooters' Hill, barely 1½ miles distant from the Royal Arsenal. Dr Stukeley in his "*Itinerarium Curiosum,* 1724," speaks of "on *Black-heath* a vast *tumulus,* now us'd as a butt for archers, hereabouts in great request till H. viiith. time, and hence the name of *Shooters' hill.*"

To the Romans has been assigned the credit of having reclaimed the great river marshes by the embankments of the Thames between Gravesend and London, for whose maintenance—so far as the Arsenal is concerned—the Government still pays annual "wallscot" dues. Walker's Thames Report of 1841 states, "The probability is that they are the work of the ancient Britons, under Roman superintendence. That they are the result of skill and bold enterprise, not unworthy of any period, is certain." Sir William Dugdale, Sir Christopher Wren, and many others, considered these great works to be of Roman origin; whilst some have supposed that they were constructed by the abbots of Stratford in Essex and Lesnes near Erith, whose abbeys were founded in the twelfth century. In the year A.D. 1236 a sudden rise of the tide caused the river to overflow the marshes, and Henry III. appointed a commission "for the overseeing and repairing the breeches, walls, ditches, &c., in diverse places between Greenwiche and Wulwiche."

Woolwich was called by the Saxons *Hulviz* (a settlement on a creek) by which name it was designated in Domesday Book A.D. 1086, and shown near "Plumestede in Chent." The name of the place has been since

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* "Environs of London." 1796.

written as Wlewic (1143. Textus Ruffensis), Wollewic, Wulewick (1044), Woolwicke, Wulwiche, Woolwych, Walwich, Wolwych (1542), Wolwich, and Woollwitch.

In the year 964, King Edgar endowed the Abbey of St Peter at Ghent with "a certain extent of land which the rustics from ancient custom have denominated Lewisham, with all its appurtenances, viz. Greenwich, Woolwich, Mottingham, and Comb." This gift was confirmed in 1044 by Edward the Confessor, and in 1081 by William the Conqueror, The Domesday Book shows that in 1086, "In the half-lath of Sudtone, and in the Grenviz (Greenwich) hundred, Haimo has 63 acres of land in Hulviz (Woolwich) which William the Falconer held of King Edward. In this estate there are 11 bordars, who pay 41 pence. The whole value is three pounds." Such is the only record of Woolwich in the Domesday Book, concerning which the contemporaneous Anglo Saxon Chronicle says, "So very narrowly did the king cause the survey to be made that there was not a single hide nor a rood of land, nor—it is shameful to relate that which he thought no shame to do—was there an ox, or a cow, or a pig, passed by, and that was not set down in the accounts, and then all these writings were brought to him."

The Woolwich garrison owed its existence to, and till 1784 was contained within, the King's Warren.* Hence it comes that the early allusions to the town represent it as being of naval, rather than of military importance. Thus, Stow's *Survey* speaks of "*Woolwich,* seated on the Kentish side, low, and not over healthful; but, by reason of its *Dock* and *Storehouses* for the *Navy Royal,* is a place well inhabited, especially by those that have their Dependance thereon. And in this Dock hath been built the best Ships of War; amongst which the *Royal Sovereign,* Anno 1637." After describing her "Three Tire of *Guns,* all of Brass; in all 100 Guns," the chronicler narrates that "This Royal Ship was curiously carved, and gilt with Gold; so that when she was in the Engagement against the Dutch, they gave her the name of the *Golden Devil;* her Guns being whole Cannon, making such Havock and Slaughter amongst them." This great ship (which was accidentally burnt at Chatham in 1696) seems to have given much satisfaction and comfort to all but those who, like Mr John Hampden, at that time objected to the heavy ship-money impost. A quaint pamphlet by Thomas Heywood ("printed by *John Okes* for *John Aston,* and are to bee sold at his shop in Cat-eaten-streete at the signe of the Buls-head, Anno 1637,") purports to contain "A True Description of His Majesties Royall Ship, Built this Yeare 1637 at *Wooll-witch* in *Kent.* To the great glory of our *English Nation,* and not paraleld in the whole Christian World."

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* A newspaper of 1739 states that "On Monday last, November the 5th, a Battallion of Guards and a Troop of Horse march'd to *Woolwich,* to quiet the Workmen in that Yard, who mutiny'd about their Pay and refused to work." Another of August 25th, 1770, contains a paragraph that "Last Saturday Morning their Majesties honoured the Regiment of Artillery with their presence in the Warren at Woolwich." On the 25th August, 1772, Dr Pollock, Professor of Fortification in the Academy, was ordered to survey Mr Bowater's house, ground, and meadow, (now site of the R.A. Barracks) Woolwich Common; and on the 28th Sept. 1772, the Surveyor General was requested "to prepare plans & estimates for building a Barrack to contain one Battalion of Artillery without the Warren at Woolwich."—*Ordnance Minutes.*

The *Magna Britannia et Hibernia, Antiqua et Nova,* 1720, mentions "Woolwich, where are kept Magazines of Bombs, Carcases, Mortars, and other Materials of the Artillery for the *Navy Royal,*" and the "Tour through the Island of Great Britain brought down to 1778," (begun by Daniel De Foe, continued by Mr Samuel Richardson and others) describe how, in Woolwich, "on the east or lower part of the town is the gun yard commonly called the *Park* or the *Gun Park,* where is a prodigious quantity of cannon of all sorts for the ships of war, every ship's guns apart; heavy cannon for batteries, and mortars of all sorts and sizes; insomuch that, as I was informed, here have been sometimes laid up at once between 7 and 8000 pieces of ordnance, besides mortars, and shells almost beyond number. Here also is the house where the firemen and engineers prepare their fireworks, charge bombs, carcasses, and grenadoes, for the public service. The royal regiment of artillery does duty at *Woolwich.*"

The Royal Dockyard at Woolwich was commenced early in the reign of Henry VIII., and Camden writing (in his *Britannia, anno* 1695) concerning "the Arsenals for the Royal Navy in *Kent,*" speaks of Woolwich having given birth to the—

Harry Grace de Dieu	in 3°	Hen. VIII.
Prince Royal	8°	Jac. I.
Soveraign Royal	13°	Car. I.
Nazeby, afterwards the Charles	7°	Car. II.
Richard, afterwards the James	10°	
St Andrew	22°	

so that men of war must have been constructed there at least as early as the year 1512. The "Henrye Grace à Dieu," (as she was sometimes called) was burnt at Woolwich in 1553. From this dockyard were launched most of the ships celebrated in the victories of Drake and Cavendish, and in the voyages of Hawkins and Frobisher.

Mr Pepys, as Secretary to the Admiralty, often paid official visits of inspection to Woolwich, where he "viewed well all the houses and stores there, which lie in very great confusion, for want of storehouses."—(*Diary,* 11 *July,* 1662). The public roads about Woolwich appear, in his time, to have been somewhat dangerous for travellers, as testify the following extracts from his Diary, "19th Sept. 1662, To Deptford and Woolwich yard. At night, after I had eaten a cold pullet, I walked by brave moonshine, with three or four armed, to guard me, to Redriffe,*—it being a joy to my heart to think of the condition that I was now in, that people should of themselves provide this for me, unspoke to. I hear this walk is dangerous to walk by night, and much robbery committed there." Again, he writes, "30th June, 1664. By water to Woolwich, and walked back from Woolwich to Greenwich all alone; saw a man that had a cudgell in his hand, and, though he told me he laboured in the King's yard, and many other good arguments that he is an honest

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* De Foe, in his *Journal of the Plague Year* speaks of "the houses which we call Ratcliff and Redriff, which they name the pool."

man, yet, God forgive me! I did doubt he might knock me on the head behind with his club. But I got safe home."

On the 10th June, 1667, the Dutch admiral De Ruyter, made his raid up the river Medway, and struck the blow at England's naval *prestige* which, exciting the whole nation, seems—as was natural—to have been most keenly felt by the then Secretary to the Admiralty. For Mr Pepys thus writes, a few days later, concerning the Woolwich defences,* "14th June, 1667. At night come home Sir W. Batten and W. Pen, who only can tell me that they have placed guns at Woolwich and Deptford and sunk some ships below Woolwich and Blackewall, and are in hopes that they will stop the enemy's coming up." And, "23rd June, 1667 (Lord's day). To Woolwich, and there called on Mr Bodham; and he and I to see the batterys newly raised; which indeed are good works to command the River below the ships that are sunk, but not above them. It is a sad sight to see so many good ships there sunk in the River, while we would be thought to be masters of the sea." A letter from Sir William Penn to Mr Pepys, dated the 15th June, 1667, and now deposited in the Record Office, reminds him of "the six ships to be sunk at Woolwich, and the eight hoys with four guns each, and, if it were possible, 4000 tons at least of stones, to be cast into the ships to be sunk."

The ships thus mentioned were sunk, according to tradition, at the head of Gallion's Reach, almost immediately opposite the site of the present T pier in the Royal Arsenal. Batteries were also constructed 17 miles lower down the river; and Mr Pepys, on the 1st July, 1667, "took coach, and, being very sleepy, drowsed most part of the way to Gravesend, and there 'light, and down to the new batterys, which are like to be very fine."

A letter from James Thruston to Viscount Conway, dated the 29th June, 1667, says, "I am almost ashamed to say that Woolwich is now in a very good posture of defence (Sir Edward Spragg being vice admiral of the squadron there) and that there is such a breach in the walls of our nation that we are forced to make inner works. Never was England brought to such an extremity, never so benumbed with such a lethargy, that, seeing our enemies so watchful, so providing, and at last so provided, we still were so resolutely blind as not to endeavour the prevention of those miseries which almost every eye could have easily foreseen."

Near the site of the present Laboratory pattern room in the Royal Arsenal there formerly stood a tall brick building owned, according to tradition, by Prince Rupert, and named after him "Prince Rupert's Tower." A wooden model of this building (the gift of C. G. Landmann, Esq.) may be still seen in the Museum of the Royal United Service Institution, Whitehall Yard, and the accompanying lithograph, from a drawing in the R.A. Institution, clearly shews its position. In was pulled down in August, 1786. That such a building, with such a name, existed in—and gave a name to—the Tower Place, is probable enough. That it was occupied permanently, as a residence, by Prince Rupert of Bavaria, is extremely doubtful; since no mention of such a circumstance is made by any writers

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* For particulars about the erection of these batteries, see p. 232.

of the day who carefully record the Prince's having resided—after his retirement from public affairs in 1673—at Spring Gardens and Windsor Castle. It seems probable that he may have occupied the house temporarily, during the construction of the batteries thrown up, under his superintendence, to protect Woolwich against the Dutch fleet in June 1667 (as more particularly described at the commencement of this paper). It is a somewhat singular coincidence that the site of the great Military Arsenal of England should be thus associated with the name of a soldier so distinguished as was Prince Rupert in the investigation of war-material manufacture. He is recorded to have studied carefully, and to have determined many important points respecting, the best composition for gunpowder; to have patented a mode of annealing cast-iron guns; to have invented the "prince's metal," or pinch-beck, with a view to its use in the casting of ordnance; and to have specially built a water-mill at Hackney Marsh for the boring of guns.

The adjoining building (now Royal Laboratory pattern room) was rebuilt by Sir John Vanbrugh in the year 1719,* and used as an office by the Board of Ordnance. In 1741 it was converted into an instruction room for the then instituted Royal Military Academy, whose warrant (issued by George II. to the Duke of Montagu) dated the 30th April, 1741, sets forth that it was intended "for instructing the raw and inexperienced people belonging to the military branch of this office, in the several parts of Mathematics necessary to qualify them for the service of the Artillery and the business of Engineers; and that there is a convenient room at Woolwich Warren, which is our property, and may be fitted up for that purpose." According to the Rules for the Royal Academy at Woolwich, 1741, it was ordered, "That an Academy or School shall forthwith be established and opened at the Warren at Woolwich in Kent, for instructing the people of the Military branch of the Ordnance, wherein shall be taught, both in theory and practice, whatever may be necessary or useful to form good Officers of Artillery and perfect Engineers."

In the British Museum there may be seen a "Plan of the 2 *Gun-Batterys* and *Bomb-Battery* in the *Warren* at *Woolwich* made by the Direction of the Hon^{ble}. Major General *Borgard* in the year 1737," and "An Accurate Plan of the Town of *Woolwich*, his Majesty's *Dockyard* and *Rope Walk*, Survey'd by *John Barker* with the *Plan* of the *Warren* as Surveyed in 1748, with a view from Prince Rupert's Walk of the Royal Academy, Laboratory, &c." On this last-named plan (where the Warren boundaries are marked as in 1716) the north wing of the present official quarters is shown as "New Barracks," the south wing as "Old Barracks:" the Brass Foundry is termed "Foundery for Brass Cannon;" the Dial Square "the Grand Square or Storehouse and Artificers' Shops," and a block of buildings on site of the west portion of the present Carriage Square is entitled "New Square or Storehouses." There are also shown "The Laboratory in whose square Shells are stored," the "Shot Park," a "Turret adjoining the Royal

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* The marks "G.R. 1719" may be seen, to this day, upon the lead hopper-heads of rain-water pipes to this building and the block of official quarters in the Royal Arsenal. Two lead tanks of stables near the Plumstead Gate still bear the dates 1720 and 1729.

Academy,"* near the site of the present Laboratory pattern room, and a row of houses occupying the ground where now stand the Arsenal Hospital and Inspector of Works' quarters. "Prince Rupert's Walk"—north of the "Storekeeper's orchyard"—consisted of an avenue of trees parallel, and close, to the river bank whence projected two practice batteries. Such was the Woolwich Warren in 1748.

A newspaper of the 24th April, 1756, relates that "The old Chapel in the Warren at Woolwich is filled with Bombs, Grape-shot, Chain and Double-headed Shot, ready to be embarked at a Minute's Warning."

It is curious to observe, in the present day, how changed have become the general features of the locality; to learn that Woolwich was a pleasant country resort for Londoners only 200 years ago—when Mr Pepys could record in his diary "28 May, 1667. My wife away down with Jane and Mr Hewer to Woolwich, in order to a little ayre and to lie there tonight, and so to gather Maydew tomorrow morning, which Mrs Turner hath taught her is the only thing in the world to wash her face with; and I am contented with it." And that, even 90 years later, the river flowing past was found so enticing to bathers as to necessitate Colonel Belford's order of the 8th April, 1757, "The first Cadet that is found swimming in the Thames shall be taken out naked, and put in the guard room."

A royal visit was paid to the Woolwich Warren on the 9th July, 1772, of which the following newspaper account is so curious, in many respects, that it must plead as my excuse for extracting the entire paragraph:—

"On Tuesday last the King arrived at this place (Woolwich). At a little before 10 in the morning his Majesty entered the Warren (preceded by 24 rope makers dressed in white with round hats decorated by ribbons, who had run before his Majesty's carriage from Blackheath) attended by a party of the light horse. His Majesty stepped out of his carriage, and was received by Lord Townsend as Master-General of the Ordnance, on the Parade, when he was saluted by a discharge of 21 twelve pounders. The guard rested their arms, and the drums and music beat the march; the royal standard was displayed on the mortar battery, and every window filled with ladies. His Majesty passed in front of the old invalids and the guard, to the new-erected foundery, where Mr Van Bruggen shewed his Majesty the various progressions of casting brass guns, such as the preparation of the clay, forming the moulds, fixing the trunnions, and the motion of the fire in the furnaces, occasioned by the subterraneous galleries that convey an uncommon blast of wind from every quarter. The King then entered the boring room, for boring guns cast solid, by an horizontal boring machine, extremely curious and well contrived (likewise the work of Mr Van Bruggen) where a 42-pounder was bored in his Majesty's presence. From the foundery his Majesty went through the gun walk to the mortar-battery, and saw several shells thrown from mortars of various diameters both for land and sea service; some ricochet granadoes were likewise thrown from howitzers.

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* The newspapers of 1758 contained an advertisement:—"Gentlemen designed for the *Royal Academy* of Artillery at Woolwich are qualified by Mr Marquois at John Street, Oxford Market." In the Rules, Orders, and Regulations issued 1764 by the Marquis of Granby, Master-General to the Ordnance, the Institution was denominated the "Royal Military Academy."

From thence his Majesty went to the Royal Military Academy, where he saw a very curious model of a fortification, together with the lines of approach, parallels, and saps, explained in a very military-like manner by the inspector of the Academy, Capt. Smith, who is said to have been 12 years in the Prussian Service. His Majesty then viewed the drawings and other exercises of the Upper Academy, explained by Dr Pollock,* Professor of Artillery and Fortification; after which he returned into the grand room of the Academy, and was regaled with a breakfast and repast."

To George III. is attributed the annual privilege still enjoyed by the Arsenal workmen of observing the second Saturday in July as a "Bean Feast" holiday. According to a local tradition, the king, shortly after his accession to the throne, was paying an *incognito* visit to the Woolwich Warren, when he chanced to come across a party of the Ordnance labourers seated on the grass and discussing their dinner of beans and bacon. Entering into conversation with them, in his characteristic manner, George III. partook of the men's dinner, and then (after disclosing himself as king) promised to obtain for them an annual holiday to commemorate the royal bean-feast in the Woolwich Warren. Such is the story. I have ineffectually tried to find some official corroboration of it, but all records are silent on the subject. Newcastle and many other English towns, have annual "Bean Feasts" holidays, and, were it not for the time of year specified in the legend, I should be inclined to attempt a more far-fetched explanation, and to connect this annual holiday at Woolwich with an ancient source, viz. that of the old Epiphany festival of Bean King which superseded the Saturnalia, on the introduction of Christianity into England.

Towards the middle of the eighteenth century, it appears that convicts were extensively employed upon the works in the Warren, and a newspaper of September, 1777, mentions that, "The Place where the Convicts are now at Work near Woolwich Warren is inclosing on the Land Side with a Brick Wall, so that Spectators will soon (if not already) be barred the Sight of those miserable Wretches on the Land Side, except at a distance."

In Hasted's "History of Kent, 1778," there occurs the following description of the Warren. "There is both *a civil and military branch of the office of Ordnance* established at Woolwich. The *civil branch* is under the conduct of a Storekeeper, Clerk of the Survey, Clerk of the Cheque, Clerk of the Foundery, and other officers, who have many inferior servants and workmen under them. The *military branch* of the Office of Ordnance is under the direction of a chief Engineer, who ranks as Colonel; two Directors, who rank as Lieutenant-Colonels; four Sub-Directors, as Majors. The Engineers in ordinary rank as Captains; the Engineers extraordinary, as Captain-lieutenants; and the Sub-engineers, as lieutenants. Besides which there are several Practitioner Engineers. Under the direction of this office, in a place called the *Warren,* artillery of all kinds and dimensions are cast; and afterwards proved before the principal Engineers and Officers of the Board of Ordnance, to which many of the Nobility and Gentry are often invited, who are afterwards sumptuously entertained by them."

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* Dr Pollock succeeded Mr Muller (upon superannuation) as Professor of Fortifications, on the 1st July, 1766.—*Board of Ordnance Select Orders, June* 22, 1766.

I know not on what authority the above statements rest. The instructions delivered 1st June, 1787, to Major General Pattison by the Duke of Richmond, Master-General to the Ordnance, specify that, "You are to take the command at Woolwich Garrison: You are to take the command at Woolwich in the Warren as well as in the Barracks, &c. &c.: You are to inspect the Civil and Military Departments of the respective Officers, Laboratory, Repository, Inspector of Artillery, and Military Academy."

In another work, the "Environs of London, 1796," by the eminent antiquary, the Rev. D. Lysons, the Woolwich Warren is thus mentioned:—"The gunwharf at Woolwich is of very ancient date: it formerly occupied what is now the site of the market place. When removed to the warren, where it now is, it acquired thence the name by which it is now called. The warren at Woolwich is the grand *depôt* of the ordnance belonging to the Navy: Within this warren is a foundery for brass canon; a laboratory (under the direction of a comptroller, a chief firemaster, and other officers) for making fireworks for the use of the Army and Navy, and a repository for military machines, both for the land and sea service, in which are also various models of bridges, fortifications, &c. All ordnance for the use of Government, as well the iron cannon made by contractors at various places, as the brass cannon cast at the foundery here, must be proved in Woolwich Warren. The chief officers of the warren are a Storekeeper (John Cockburn, Esq.) clerk of the Cheque, clerk of the Survey, &c."

On the 25th March, 1779, there was exhibited before the Society of Antiquaries (see *Archæologia*, Vol. VII.) "an elegant brass weapon dug up the last summer in the great marsh adjoining to Woolwich Warren, on making a boundary canal to the ground purchased for enlarging the Warren. This weapon is very perfect and in fair preservation, tapering to a point, being broad at the haft, into which it was let in, and fastened by two rivets of the same metal."

A writer in the *Gentleman's Magazine* of August, 1798, rapturously describes the Warren as "an immense repository of military arts, the *palladium* of our empire, where one wonder succeeds another so rapidly that the mind of a visitor is kept in a continual gaze of admiration!"

On the occasion of a second royal visit to Woolwich—that of George III. (accompanied by the Queen and Princesses) on the 9th April, 1805—the title of "Royal Arsenal" was conferred upon the ordnance establishment in the Warren.

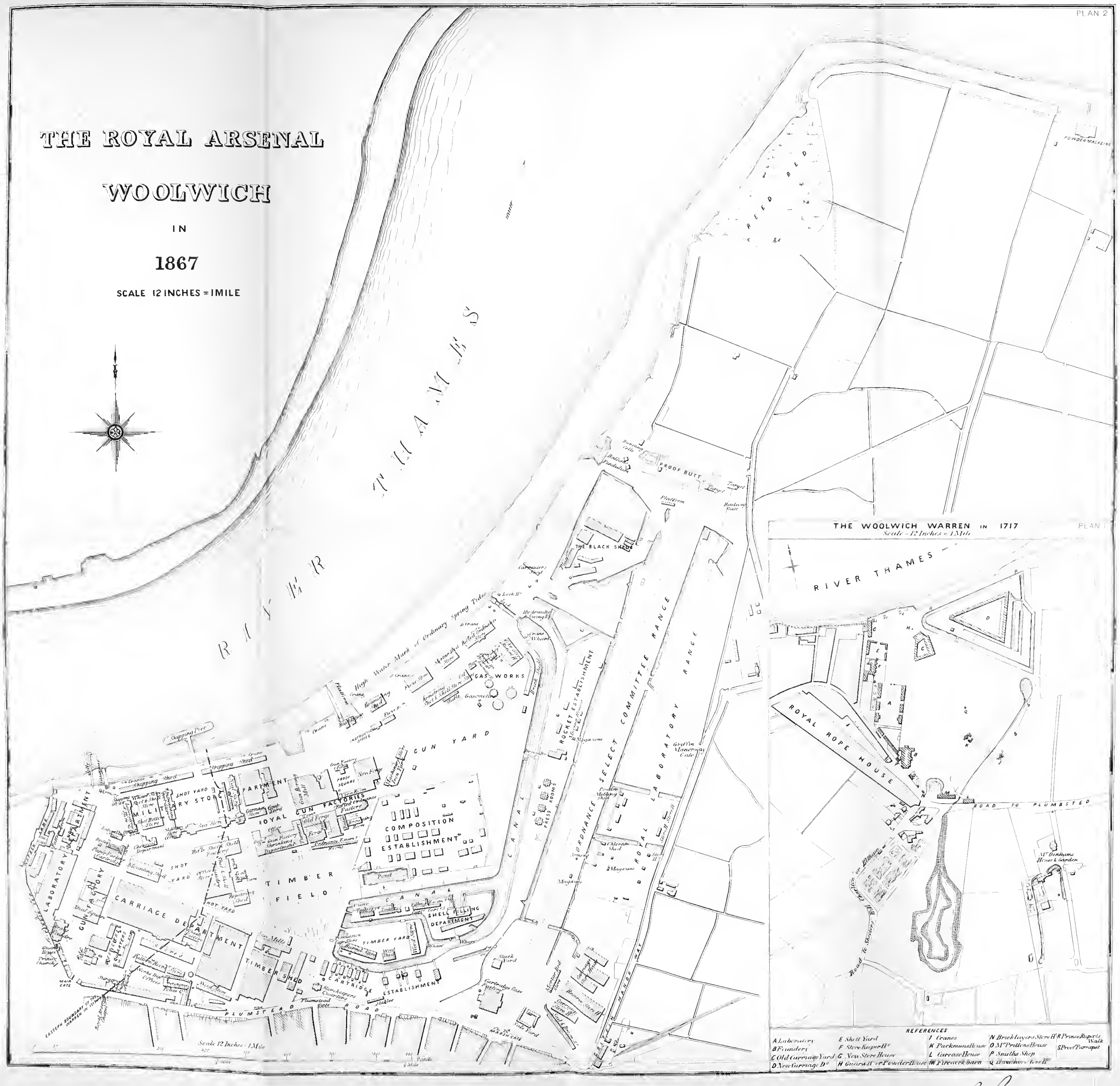
In the *Gentleman's Magazine* of July, 1805, the incident is thus recorded. "Thursday, June 27. The Ordnance Board have signified to Gen. Lloyd who commands the artillery at Woolwich, that the *Warren* at that place is no longer to bear that name; but from this time to be denominated the 'Royal Arsenal!' The old name had its origin from the place having actually been a *rabbit warren*, but the name of one of the tamest of all animals was certainly ill-suited to the nature of the place. On the recent royal visit to what is called the Warren, where all ordnance, stores, ammunition, &c. are lodged, his Majesty noticed how little appropriate the name was to the place, and suggested the propriety of changing it to that of 'Arsenal'. The Master-General admitted the justice of the idea, and instantly adopted it; henceforward, therefore, in compliment to his Majesty's suggestion, the Warren is to be called 'The Royal Arsenal.'"

THE ROYAL ARSENAL WOOLWICH

IN

1867

SCALE 12 INCHES = 1 MILE



G E Grover
Lieut. R.E.

The etymology of the word is said to be *arx navalis,* whence the Romaunt word *arthenal,* signifying generally a "citadel," though primarily it meant simply a "naval citadel."

The Royal Military Academy on the Common—whose construction cost £150,000—was opened on the 12th August, 1806; but the Duke of Wellington ordered, 14 years afterwards, that "Cadets when reported capable and fit to have commissions in the Artillery or Engineers shall, till vacancies occur in those Corps respectively, be removed from the Upper Academy to the buildings in the Arsenal; they are there to learn Repository exercises, also the Laboratory duties, &c."

In the January of 1821, the Lower Academy was broken up, but again formed in 1840 for a Practical Class of 20 cadets. In 1847 it was enlarged to receive 40 cadets, but finally removed from the Royal Arsenal in the year 1856.

In the west lodge of the Main Gate, a small stone let into the wall bears the following inscription :—

This Entrance to the Royal Arsenal
was planned, and the Gateway constructed
by order of
General Viscount Beresford, G.C.B., G.C.H.
Master General of the Ordnance,
in the tenth Year of the Reign of
His Majesty King George IV.
A.D. 1829.

In 1844 the custody of the Royal Arsenal was transferred from the garrison guards to the metropolitan police, for the more efficient protection of the Government stores from theft, and the long river frontage from smuggling.

In concluding these notes, their compiler is conscious how much he has omitted from what has already grown into too lengthy and discursive a paper. He is, however, anxious to delay no longer the appearance of such materials for a history of the Royal Arsenal as the foregoing notes with which he has chanced to meet. It would be a pity that, for want of graceful arrangement, they should remain any longer unknown and useless; whilst they might prove acceptable to many who are interested in the subject. For the which reasons the writer trusts to be pardoned the length of his paper.

SOME ACCOUNT
OF A
PRUSSIAN DIVISIONAL MANŒUVRE
IN THE
RHINE PROVINCE,

SEPTEMBER, 1868.

BY MAJOR W. H. GOODENOUGH, R.A.

I ARRIVED in Coblentz on the morning of the 7th September, and heard from a Staff Officer at the Head Qrs. Office that a divisional manœuvre was then going on near Saarlouis. The officer very kindly gave me the name of a village, *Lebach,* near St Wendel, where the Divisional Head Qrs. were that day, and also a note to a brother Staff Officer who had proceeded two days before with General Herwarth v. Bittenfeldt, who commands the Coblentz *corps d'armée,* to be present at the manœuvres.

I arrived at Lebach too late that night to see any one. The Head Qrs. Staff were quartered in various houses round about as in war. Early in the morning, having first been to the officer to whom I was recommended, I presented myself at General Herwarth's lodging and was received by him without any ceremony, not even the intervention of an aide-de-camp—(personal staff seems unknown in Prussia). The *ordonnanz* simply announced me as an English officer. I was of course in uniform. The General was most kind, he ordered a Hussar horse for me, and bade me mount and ride out with him at eight o'clock.

The weather was splendid, and the country beautiful—a fine rolling upland, well wooded and well peopled. I passed the next three days most enjoyably, my reception continued to be most kind, my horse was brought for me every day, and my baggage was carried with that of the Head Qrs. wherever we marched. *Au reste,* I was relieved to find that I was able to live at my own charges at the country inns.

Independently of the military interest attaching to it, such a trip would be most enjoyable for its own sake.

I found that the division had been out since the 3rd September, quartered in the villages round about, and carrying out a plan of operations of which the general scope had been pre-arranged and made known.

There were present at the manœuvre:—

General Herwarth v. Bittenfeldt, Commanding *corps d'armée*.
Maj.-General v. Schlottheim, Chief of Staff of do.
Lt.-Gen. v. Barnekow, Commanding 16th Division, with one chief of staff, and one adjutant.
Maj.-Gen. Graf Gneisenau, Commanding a brigade, and one adjutant.
Maj.-Gen. v. Glümer, Commanding a brigade, and one adjutant.
Colonel v. Rantzow, Commanding cavalry, and one adjutant.

The force comprised two brigades, each of two regiments containing three battalions, thus twelve battalions in all. There were six batteries on the peace establishment of four guns each, three of these were Horse Artillery armed with 4-prs., two field batteries armed with 6-prs., and one field battery armed like the Horse Artillery with 4-prs. There were present also five squadrons of Hussars; a lancer regiment which should have been present had been sent back to quarters on account of glanders.

The general system on which these manœuvres of the Prussian army are carried on in peace has long been established, it was fully detailed with much other interesting matter in the little Book of Instructions published in 1861, entitled "Allerhöchste Verordnungen über die Grösseren Truppenübungen." I found that the rules therein laid down were closely followed.

The great peculiarity, which gives such a superiority to this system of field manœuvres lies in the character of reality which is given to the whole of the operations; in my opinion our manœuvres are too often on the plan of a gigantic drill field day, and those of the French, though workmanlike, fail in interest from the laborious detail of their plan; the Prussians, on the other hand, place two opposing forces in the field, give them a strategical plan of operations, and then leave the two commanders to plan their own tactical movements; the troops work every day over fresh unknown ground, and so the interest never flags. The general of division superintends the whole, issuing as before said all strategical orders. The General commanding the *corps d'armée* with his Chief of the Staff is present, with no function but to observe and subsequently criticise.

A law permits the troops to be exercised anywhere over the country; an officer is detailed to accompany each detachment to take note of any damage done to the crops, &c. (at this season of the year, September, it cannot be very heavy) and when the manœuvres are over a commission consisting of a regimental officer, an intendant, and a civil *employé* assembles and assesses the compensation to be paid to individuals. The system does not appear to lead to dissatisfaction, the troops seemed always well received, and the population turned out every day in numbers on every eminence to witness the show.

The daily marches were from thirteen to eighteen English miles including the manœuvres. The troops, except on one day when they all bivouacked, were quartered in the peasants houses in the villages, the distances traversed in manœuvring necessitated their taking up fresh quarters nearly every day.

Except on the last day, when the whole division was united for manœuvres against an indicated enemy, "*markirter feind,*" the troops were divided into bodies of unequal strength, the north detachment and the south detachment, and different officers were put in command from day to day who manœuvred against one another, being bound by the strategical plan laid down beforehand, but otherwise acting quite independently.

The first manœuvre which I witnessed was on the 8th, see p. 256, and it proved a very instructive one. General v. Glümer commanded the north detachment (which was distinguished by carrying green boughs in their helmets) and was opposed to a weaker detachment supposed to have been sent out from a *corps d'armée* understood to be engaged in blockading Saarlouis. This south detachment being inferior in numbers, and having no good position was compelled to retreat. Its rear guard was engaged in taking up a position at Heusweiler when the general commanding the division, v. Barnekow, sent an order to the officer commanding the south detachment informing him that the investment corps had retreated, see p. 258, and that in consequence his retreat was no longer to be directed on Saarbrücken but towards Illingen, at a right angle therefore to the former line, and towards the east. Similar information was at the same time given to the north detachment. The generals had now to extricate themselves as best they could. The result was interesting and instructive, shewing the importance of a good eye for country, and of having the habit of rapidly and correctly interpreting a map. No sooner had the attacking detachment penetrated the village and ascended some heights beyond, than it was perceived that the enemy had missed the direct line of retreat, and that he had left some commanding ground which was on the direct line of retreat entirely unoccupied; the mistake was speedily perceived and a struggle took place for the possession of this commanding ground which was obviously the key of the position; it was too late however, and the heights, though occupied for a moment by the retreating force with artillery and a few infantry, had to be abandoned. Then the General Halt was sounded, and this very interesting day's manœuvres were terminated by all mounted officers being summoned to hear and take part in the usual *Kritik,* which always takes place at the close of each day, when the general who has been quietly riding about making his observations, remarks on everything which has come under his notice, and any officers who have occasion to do so frankly explain their conduct in any particular instance.

On this day both detachments bivouacked in the open without any other shelter than the low thatched wall, which they quickly put up in a circle of about 24 feet diameter round their bivouac fire; as on every other day, outposts were thrown out by both sides, these consisted of *feldwache, replis,* and the *gros der Vorposten,* or serjeants' pickets, pickets, and a main reserve to which some cavalry and artillery were attached.

The practice of bivouacking gives useful experience; I had never seen it done before on a large scale, and doubtless the greater portion of our officers are equally inexperienced. The Prussians bivouac in line of close columns at small intervals, artillery in rear; the order is too close in their own opinion, but it gives great facility of supervision.

There is an art even in making a bivouac fire with which all troops should be acquainted. The Prussians drive a stake upright into the ground where they intend the centre of their fire to be, and then build a pillar or mound of earth or sods around the stake about 2½ feet high, round this they pile the logs of wood. With the straw which is issued to them in bivouac they twine a rope with a fringe of long straws (like our straw edging in gentlemen's stables), with this and a number of stakes they make a slight wall in a circle of about 24 ft. diameter round the fire, and within this circle the men lie in some degree protected from wind and weather.

Arms are piled, and knapsacks, &c. laid in rows on the ground where the columns would fall in.

An important point in the Prussian system is the employment of senior officers as *schied's richter* or *referees;* two of these were always in the field, they were distinguished by a white handkerchief, bound round the arm, their duty being to prevent collisions between the troops, to determine in cases of dispute when one or other of the opposing bodies should yield, or, in cases where in actual war one of them would have suffered very severely or have been liable to be taken prisoners, to decide, whether it should retire from the field altogether, whether it should retire to a certain distance, or whether it should be regarded as *hors de combat* for a given time. At our field days, when the force is divided, detachments have sometimes been made prisoners, this is humiliating and may lead to quarrels, the Prussian system of *schied's richter* or *referees* prevents any difficulty from this source.

During the engagements the expenditure of ammunition was small compared to ours; the infantry used 6 to 7 rounds per man per day, artillery 10 to 15 rounds per gun, thus economy is ensured and the contraction of a wasteful habit on service is avoided.

On the field orders of importance were frequently sent in writing, an orderly being then employed instead of an officer; much trouble is taken to ensure success in this respect.

I noticed that several of the cavalry trumpeters were made available in the field as orderlies; the Divisional General usually caused himself to be accompanied by two or three, this was of great advantage when any sound of general import had to be given, as three trumpeters blowing together could be heard to a great distance. With our troops I have often seen one trumpeter made to sound over and over again, and perhaps gallop half a mile and sound again before he could be heard, whence delay and irritation.

The advantage to officers and troops of being exercised over new ground presenting new forms and features, and cultivated as ordinarily met with in campaigning must be very great; a real experience is gained which perhaps no other system can give, judgment and *coup d'œil* are improved, artillery and cavalry learn what they can do in heavy ground and the operations are regarded by all with enhanced zest and interest. Every officer almost has his staff map; it is constantly in his hand, and he learns to work his way across a new country by its aid. On both days when the force I saw acted in two detachments, the space of ground worked over was so great, and the roads so far intricate, that success or failure depended in great measure on their proper appreciation by aid of the map.

That this would often be the case in England is surely a reason why our officers should have all the advantages which a system of manœuvring troops in the open country can give, at present the only experience of the kind our officers have is gained in the hunting field, and we should be in bad plight without it, but, alas! we cannot all afford to hunt. Really, though we have no law like the Prussian, I believe that manœuvring in the open country in England would not by any means be impracticable. Of course a country not too much enclosed must be chosen, such as is offered by our *Downs* districts. Farmers who allow hounds over their growing crops would not be very difficult to persuade to allow troops to go over their stubbles in September; bye and bye perhaps we should see the counties ready to settle the compensation by local arrangement, in order to ensure the coming of a large body of troops (including it may be hoped Volunteers and Reserves) among them, who are always good customers in many ways. The lines of operations should be by lines of railway, and the troops would live in camps pitched by the side of railways, thus the expense of road transport could be avoided. Our railways are now so numerous and they triangulate the country so closely that it would not be difficult to plan a *manœuvre campaign* which would give the requisite amount of moving about and yet leave the troops within reach of their camps by the railway side at night.

The presence at the manœuvres of a General in chief command, who with his Chief of the Staff has no duty but to criticise, has an admirable effect. At the *Kritik* after each day's manœuvres he would descant at length upon the good conduct or upon the errors which he had had leisure to notice. Mistakes were not infrequent, but were always pointed out. I heard General Herwarth particularly disapprove of too extensive turning movements of a strategical nature, he made a pointed distinction between the expediency of the practice of flanking movements of this description and those of a tactical kind, and commended the latter as developing the tact, adroitness, and *coup d'œil* of the individual commanders, and as promising the best results when skilfully employed, whether by skirmishers or infantry detachments alone or combined with other arms.

I also heard General Herwarth condemn the outposts as not being sufficiently far forward and the night pickets as not being posted early enough. This seemed indeed a bad habit the troops had; in the opinion of the Chief of the Staff, General v. Sclottheim, who made the campaign of 1866, whenever the ground admits of it the cavalry should furnish an outer line of pickets by day and the infantry should occupy also in the day time an inner line of pickets on the very line which it is intended they should hold at night. Thus they would become well acquainted with the ground while all is in their possession and it is yet daylight.

Remarks on Infantry. Vide p. 262.

The mode in which the infantry work across country differs much from ours and deserves attention. The habitual use of columns when moving from point to point even within range of artillery seems necessary though it has its evils. I conceive that it is impossible to move across country, or even for any distance, in lines, and if possible it would not be expedient, as the undulations of ground which would hide a column fail to hide the line of a battalion at war strength.

It is true that the Prussian columns were frequently visible under fire, but they would be again quickly concealed, whilst all the time they preserved *a flexibility of direction* and a rapidity of motion not to be hoped for from a line.

To enter more into detail, the most important feature in the Prussian mode of manœuvring infantry is the system of moving in company columns; the company is the fourth of the battalion, and on war strength equal to 250 men; the captain is mounted, the company column is six men deep, when the battalion is in the first line all four company columns may be formed at deploying intervals, or as is more usual, the two centre columns may be contiguous and the flank columns at deploying intervals; this splits up the battalion without dismembering it, and appears a most happy application of the principle of columns, it gives independence and rapidity of movement to a marked degree.

The skirmishers may be thrown out from each company or from the two flank companies; the skirmishers of each company cover its front, the whole battalion therefore may either have a connected line of skirmishers or two or four broken lines.

A battalion in line in covering its front with skirmishers, at first sends two skirmishing subdivisions to the front round the flanks, these throw out one or more sections (4 to 6 files), thus the flanks or extremities of our line are first covered, if more skirmishers are required they are supplied from the remaining skirmishing subdivisions and extend inwards from those first formed till in the limit the entire front is covered with a thick line of skirmishers.

It is a rule which illustrates the good division of labour and chain of responsibility in the Prussian service that, "to facilitate control through their leaders the skirmishers of each section (4 to 6 files) work together as a group; the under officers are told off to the different sections, between the different groups (in open ground) an interval of a few paces is allowed that the under officers in command may better supervise their men. The under officers are not obliged to remain at any particular post, but place themselves wherever their presence is most required."*

The general principle of Prussian tactics being to gain a position wherever possible on the enemy's flank, they hold that it is neither necessary nor wise to advance and open fire uniformly on every part of a front, even if it be only about 200 or 300 yards. It is sufficient to carry the commanding points of the ground, when the enemy must yield the lower ground, or be destroyed, or cut off.

Each company having its captain mounted is a unit in itself and is capable of *quasi* independent action. It would seem that such an organization is well calculated to enable the most to be made of such a system of tactics as the above. It cultivates the address and developes the efficiency of a comparatively large number of officers in the battalion.

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* See Witzleben, Heerwesen, &c. Berlin, 1868, Sect. II. p. 125.

In an advance on the enemy, it is to some one of these that the favourable opportunity is presented, having the means he takes advantage of it, and so the object of the commander and general purpose of the battalion is gained, or if the company is repulsed another takes up its work without any complication in the battalion.

It is very rarely that the whole battalion is deployed into line, nor is there the same occasion for deploying when the battalion can be so readily broken up into its four component parts, either of which can be deployed separately. I myself heard General Herwarth find fault with a battalion which he had seen deploy into one line to fire, he said in his opinion it was rare to find a sufficient length of even ground to make it really worth while to deploy and deliver the fire of the whole of a battalion on war strength of 1000 men; he preferred the deployment of companies, which could be easier employed precisely where wanted and whose fire would then tell effectively.

The *volley fire* of the company or of the subdivision is much employed, notably in connexion with skirmishing; if the skirmishers are being overpowered at any point, so that a heavy fire is particularly required to be delivered from part of a line of skirmishers, a subdivision (*zug*), or the main body of the company which has been in support, doubles up into line with the skirmishers, fires a rapid succession of volleys till the purpose is accomplished and again retires. Such volleys are called *Kleine salve;* it is a mode of delivering fire which is worth calling attention to, it seems much relied on in Prussia, and with justice.

The number of rounds now carried in the field by the Prussian soldier is 80, in the war of 1866 it was 60; with regard to the general question of preventing the too rapid firing away of cartridges, it appears that this is met in Prussia by giving the battalions the fewest possible opportunities of firing indiscriminately; independent file firing is recognised in their drill but seems very seldom resorted to the system of firing volleys rapidly from small bodies taking its place, these are delivered by word of command and so the men are kept under control. At the manœuvres on one occasion, I saw a company going through the motions of firing repeated volleys by word of command without ammunition, I thought naturally that they had expended all they had and were aiming only for show, as they were standing on the defensive in a critical position; suddenly, however, the officer indulged his men with one real round; it was simply that he had his men well in hand and was husbanding his ammunition. As was said above, not more skirmishers are sent out than necessary, and long lines are seldom deployed to fire, whence results much economy in expenditure of ammunition.

Artillery. The field battery equipment is light and adapted for rapid movement over long distances, six men can be carried with the gun, independently of the wagon, viz. a mounted No. 1, three men on limber, and two on axle-tree seats, these seats are safe and comfortable, they have cylindrical springs of india-rubber which it is said wear very well.

The gun carriages have unequal wheels in carriage and limber, and they look clumsy, but they can lock in a right angle, and their centre of gravity being very low they are very difficult to upset.

Lightness and capability of rapid movement is more than ever necessary now with field batteries, this follows in consequence of the increased efficiency of the guns at long range. At the manœuvres this could be readily appreciated: the country being one of wide swelling rolling hills—the features on a grand scale—the artillery was often obliged to remain a long way behind to cover advances of the infantry and then would be compelled to move rapidly for a long distance to come to the front again.

Cavalry. The cavalry which I saw in the field (5 squadrons hussars) were particularly noticeable for their intelligence and for the admirable manner in which they were instructed in outpost duty—they shared this duty with the infantry co-operating with them in supplying pickets and patrols, and taking the duty of carrying communications between the advanced posts, reserves, and main body. It seemed to me as a spectator that there was little marked separation in feeling between the different arms of the Prussian service, a common military spirit unites the whole to a degree I have not known in other countries.

The cavalry (and artillery also) are furnished with stable jacket and trowsers of a thick brown holland stuff, these are carried across the seat of the saddle; their usefulness is great, after the heat of the march the soldier pulls them out *without disarranging his kit,* puts them on, and is at once in comfort. As our soldiers' clothes are uncomfortably hot even in an English summer, and as we cannot hope to have cooler weather in any country in which we might have to serve, it would be very desirable that we should adopt at least canvas trowsers of this kind; at present men wear dirty old cloth trowsers in stables, &c. till they look disreputable and are almost indecent.

The cavalry carry no valises, the cloak is rolled and fastened to the cantle of the saddle, the kit is carried part in the wallets part across the seat and part is laced into the saddle seat; thus the rider's hand is brought low (which with us is the great desideratum) there being nothing but the shabraque above the wallets.

Tight pantaloons and Hessian boots are about being introduced into the service for the Hussars.

I was much impressed with the efficiency attained by all arms in the short period of their service. Unremitting hard work and a scrupulous attention to the essential points of efficiency, with a disregard of everything else, is the excellent rule of the Prussian service.

It seems probable and I think the experience of officers who have commanded young or newly raised battalions or batteries would corroborate this, that more is to be got in the way of soldiering out of bodies composed entirely of young men, and that they have more zeal in learning their duties and hence attain to a higher degree of efficiency than battalions composed, as is usual with us, of old and young soldiers together, where the knowledge and habits acquired by the young comes to them filtered through the old soldiers, who are not always the best *mentors.*

APPENDIX A.

GENERAL IDEA FOR THE MANŒUVRES OF THE 16th DIVISION, 4th to 10th SEPTEMBER, 1868.

[Translated from the Orders published by Lieut.-General v. Barnekow.]

An army from the westward marching through the Palatinate towards the middle Rhine has detached a corps of about 15,000 men against *Saarlouis* with the object of if possible capturing that not yet fully armed fortress by means of bombardment and an attack *de vive force.*

Whilst an eastern army concentrated behind the Rhine prepares itself to assume the offensive—the reinforced garrison of *Treves* is, in consequence of the investment of *Saarlouis,* put in movement towards that fortress in order to assume an offensive attitude towards the investing corps, and if possible cause it to give up its projected attack.

This north detachment has reason to expect to be joined within a short period by reinforcements by the route through Berncastel-Hermeskeil.

The railway bridge at Saarbrücken is blown up.

SPECIAL IDEA FOR THE NORTH DETACHMENT ON THE 8th SEPTEMBER.*

Detachment Commander Major-General v. Glümer.

From information received from Saarlouis the investing corps has moved off towards Saarbrücken on the 7th September, after leaving a weak detachment on the right bank of the Saar.

The Commandant of Saarlouis contemplates being able to move early on the 8th, by way of Holtzweiler and Sprengen and operate on the flank of the south detachment bivouacked near Heusweiler (supposed).

The north detachment has to attack the enemy energetically and throw him back on Saarbrücken, and at the same time to procure information relative to the direction of the march of the blockading corps.

(Signed) v. BARNEKOW.

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* It was on this day that the south detachment when it reached Eiweiler received a sudden order that in consequence of the investment corps having quitted Saarbrücken it was to change its line of retreat and retire on Illingen instead of on Saarbrücken—a difficult movement.

Disposition.

The detachment stands to-morrow morning at half-past eight to the north of Landsweiler. * * * * The "advanced guard" moves on Heusweiler; the "*gros*" and reserve will be employed (subject to modification by the reports received from the advanced guard) against the enemy's left flank.

Reports will find me at first with the "advanced guard," then with the "*gros*."

Any necessary retreat will be made on Lebach and eventually on Saarlouis.

Ordre de Bataille.

Advanced Guard.—Colonel Mettler.

1st Battalion Regiment, No. 40.
1st do do No. 70.
1st Squadron Hussar Regiment, No. 9.
6th 4-pr. Battery.

Gros or Main Body.—Colonel Freiherr v. Eberstein.

2nd and Fusilier Battalion Regiment, No. 70.
2nd and 3rd Battalion Regiment, No. 40.
2nd Squadron Hussar Regiment, No. 9.
6th 6-pr. Battery.

Reserve.—Lieut.-Colonel v. Wittich.

1st Battalion Regiment, No. 69.
3rd Horse Artillery Battery.

(Signed) v. GLÜMER.

LEBACH, 7th September.

SPECIAL IDEA FOR THE SOUTH DETACHMENT ON THE 8th SEPTEMBER.

Detachment Commander Major-General Count Gneisenau.

The south detachment has received from Saarbrücken on the evening of the 7th September the following order from the commander of the former investing corps:—

"I contemplate commencing the march from Saarbrücken by Homburg towards Kaiserslautern with the troops hitherto engaged in investing Saarlouis, with a view to rejoining the west army. To insure my withdrawal in safety, the south detachment is to hold the Lebach-Saarbrücken high road obstinately, retiring in case of necessity on Saarbrücken.

Disposable Troops.

2nd and Fusilier Battalion Regiment, No. 69.
Three Battalions, Regiment No. 81.
3rd, 4th, and 5th Squadrons Hussars Regiment, No. 9.
5th 6-pr. Battery.
1st and 2nd Horse Artillery Batteries.
Sanitary Detachment.

Rendezvous south of Eiweiler.

Commencement of hostilities 8.30 a.m.

Disposition.

"The troops on outpost duty will form the advanced guard.

"At 6 a.m. the infantry pickets (*feldwache*) on the flanks are to be withdrawn, in their place the 5th squadron Hussars is to watch the entire front, keeping the flanks under close observation, and especially the right flank towards Eppelborn, in order to be able to make an immediate report of any turning movement which the enemy may commence to undertake. The infantry and artillery of the outposts assemble in the position assigned to the latter, west of the road from Landsweiler to Eiweiler; they will be afterwards reinforced from the rendezvous with the remainder of the cavalry and of the two horse artillery batteries.

"The *gros* and reserve remain halted at Eiweiler.

"Further necessary orders will be issued during the engagement."

Ordre de Bataille.

Advanced Guard.—Lieut.-Colonel du Russis.

Fusilier Battalion, 81st Regiment.
5th and 6th Companies, 81st Regiment.
1st and 2nd Horse Artillery Batteries.
3rd, 4th, and 5th Squadrons Hussar Regiment, No. 9.

Gros.—Colonel v. Sell.

1st Battalion, 81st Regiment.
2nd Battalion, 69th Regiment.
7th and 8th Companies, 81st Regiment.
5th 6-pr. Battery.

Reserve.—Major v. Salicki.

Fusilier Battalion, 69th Regiment.
Sanitary Detachment.

(Signed) Graf GNEISENAU.

HEUSWEILER, 7th September, 1868.

SPECIAL IDEA FOR THE NORTH DETACHMENT, ON THE 9th SEPTEMBER.

Detachment Commander, Col. v. Rantzow.

On the evening of the 8th Sept. information reaches the north detachment that the west army is retreating on Kaiserslautern, whither the east army is forcing it back. It is also confirmed that the corps of investment has already reached Homburg.

The commander of the north detachment determines to feel for the enemy on the 9th near Illingen with the intention of, if possible, forcing him off the line of retreat on the Palatinate.

* * * * * * *

Commencement of the march out of the bivouacks, 8 a.m.

(Signed) v. BARNEKOW.

Disposition.

After having searched the ground in the front and in the direction of Illingen, Gennweiler, and Mergweiler with patrolling parties of Hussars, the detachment will commence the advance on Illingen at an hour to be hereafter named in the *ordre de bataille* given below. The troops forming the outposts remain at their posts till the detachment marches, and then enter the order of battle.

The advanced guard directs itself on Steinärtshäuser, Gennweiler, and Illingen, endeavouring as far as possible to close up with the enemy, whilst the *gros* marches off by Wahlscheid-Göttelborn towards the Galgenberg seeking in accordance with the orders received to force the hostile detachment off their line of retreat on the Palatinate.

The reserve will follow the advanced guard at the proper distance of the 2nd line as far as Steinärtshäuser, where it will remain for further employment.

All reports will find me at first with the advanced guard, and later with the *gros*.

In case of need the retreat will be by Eiweiler towards Lebach.

Ordre de Bataille.

Advanced Guard.—Colonel Mettler.

2nd and Fusilier Battalion, 70th Regiment.
6th 4-pr. Battery.
Half 1st and 2nd Squadrons, 9th Hussars.

Gros.—Colonel Freiherr v. Eberstein.

Three Battalions, 40th Regiment.
1st Battalion, 69th Regiment.
Half 1st Squadron, 9th Hussar Regiment.
3rd Horse Artillery Battery.

Reserve.—Lieut.-Colonel v. Wittich.

1st Battalion, 70th Regiment.
6th 6-pr. Battery.
Sanitary Detachment.

HEUSWEILER, 8th September.

(Signed) v. RANTZOW.

SPECIAL IDEA FOR THE SOUTH DETACHMENT, 9th SEPTEMBER.*

Commanding Detachment:—Colonel v. Beyer.

The south detachment has received an order from the heretofore investing corps, to operate for the future independently and in such a manner as to hinder the opposing hostile detachment from disturbing the line of operations or the flanks of the west army on its retreat through the Palatinate. In the case of a further movement in retreat being necessary, the direction by Ottweiler on Kaiserslautern is indicated.

The south detachment determines to await the enemy's forward movement in the line of the advanced posts, and if necessary to retire subsequently on Ottweiler.

Disposition.

The advanced guard will protect the detachment by reconnaissances of cavalry, which will be pushed as far forward as may be practicable on the flanks. The infantry and artillery of the advanced guard will defend the line of the advanced posts, and will as may be requisite either be supported by the troops of the *gros*, or will fall back on them, according to circumstances. I will be at first with the advanced guard, and subsequently will give further orders from the *gros*. The retreat when necessary will ensue in the direction of Stennweiler.

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* The movements of the south detachment this day were blamed for want of decision, because the whole force was drawn up and awaited the enemy as above detailed, though there was no intention of defending the position obstinately, and when the enemy came on the defenders retired down hill under great disadvantages of ground.

Ordre de Bataille.

Advanced guard.—Major de Barres.

1st Battalion, 81st Regiment.
3rd Squadron, 9th Hussars.
6th 6-pr. Battery.

Gros.—Colonel v. Sell.

2nd and Fusilier Battalion, 81st Regiment.
2nd Battalion, 69th Regiment.
1st Horse Artillery Bàttery.

Reserve.—Major v. Salicki.

Fusilier Battalion, 69th Regiment.
4th and 5th Squadrons, 9th Hussars.
2nd Horse Artillery Battery.
Sanitary detachment.

APPENDIX B.

Division of a battalion of Prussian infantry.

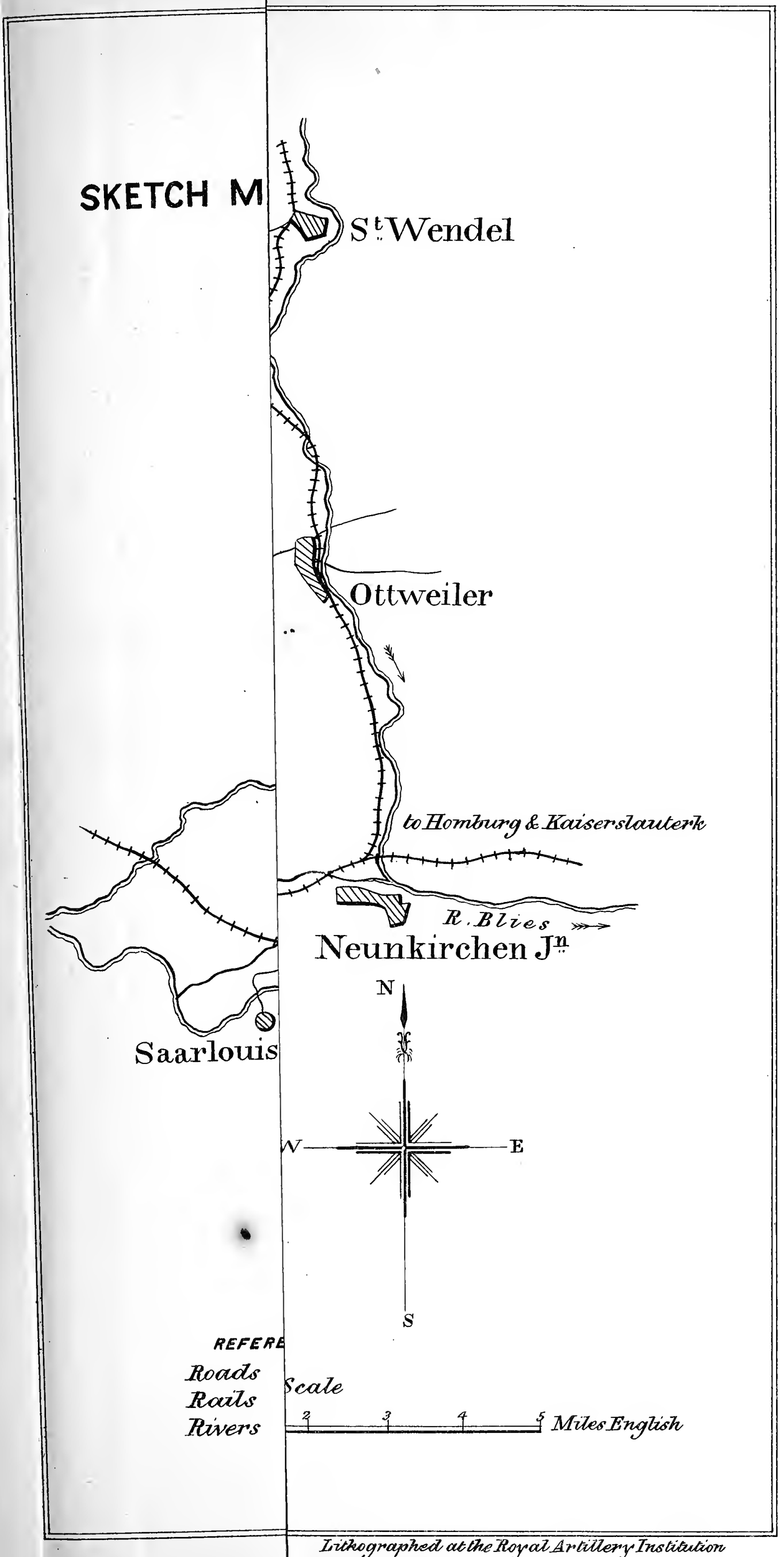
One battalion has 4 companies, say of 250 men each.

Each company formed in parade order three deep has two *zugs* or subdivisions.

The third rank of the company when detached for its special duty of skirmishing, forms a third *zug,* which is thus the third part of the company.

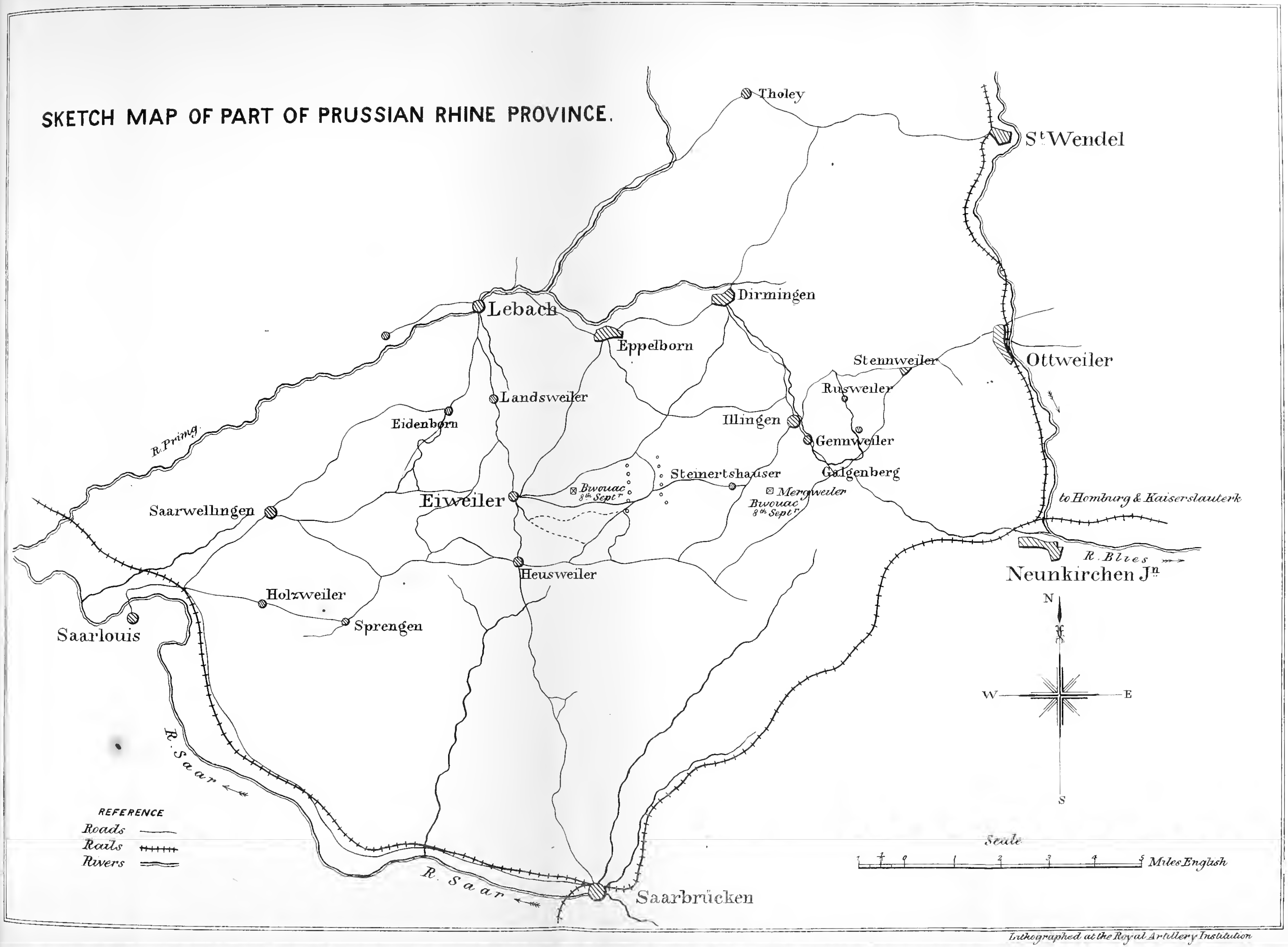
Each *zug* has as many sections as will enable each section to have from 4 to 6 files, say 8 sections, these sections when employed in skirmishing may be called *fire groups.*

The company column is a column of three *zugs,* each two deep.



Lithographed at the Royal Artillery Institution

SKETCH MAP OF PART OF PRUSSIAN RHINE PROVINCE.



Lithographed at the Royal Artillery Institution

ERRATA.

Page 264, line 30, *for* "$\frac{7}{8}$ to $\frac{3}{4}$ of a carriage," *read* "$\frac{1}{2}$ to $\frac{2}{3}$ of a carriage."

" 269, 3rd line from bottom, *after* "Intendantur," *insert* "a railway official."

" 270, 16th " " *for* "or the Route," *read* "on the Route."

ORGANIZATION

FOR THE

TRANSPORT OF LARGE BODIES OF TROOPS ON RAILWAYS.*

BY CAPTAIN J. T. BARRINGTON, R.A.

SECTION I.

System and General Principles.

1. A concentration of troops dispersed over an extended area, is most efficiently performed by a simultaneous, prompt, and regularly sustained employment of all the independent lines leading from the area where peace is disturbed into that where the concentration is intended.

2. The transport of troops, horses, and *matériel* continues until the destination is reached without change of carriage, provided the lines are in direct intercommunication, and consequently permit of the passage of carriages from one to another. Empty wagon trains return, as a rule, immediately to the district of embarkation, and receive such alteration in their composition as may be necessary at the stations of arrangement which are conveniently selected on the several lines, and provided with material for reserve and supply.

The time table of each line regulates the arrival and passing of laden and empty trains at the stations, precedence in despatch being given to the full trains. The proper succession of the trains is thus secured.†

The employment of return trains for military purposes, such as the transport of detachments of men and horses, army *matériel,* commissariat supplies, &c. is admissible provided the transport-in-chief to the front, the regularity of the journeys, the composition and succession of the trains, are not interfered with.

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* From the Prussian Regulations for Military Transport on Railways. Berlin 1867.

† In a journey not exceeding 40 miles (German), wagons can be reladen on the third day; in a journey of from 40 to 80, or perhaps 90 miles, on the fourth day; and on the fifth day in a distance of from 80 to 120 miles. This is styled a 3, 4, or 5-day rotation of trains.

3. The locomotives and persons required for their service, are employed over the same extent of rail only, as they are accustomed to traverse in time of peace. In unavoidable and exceptional cases care is to be taken to exercise the drivers by preliminary trial-trips over those portions of the lines with which they are unacquainted.

4. In the application of the preceding principles there can on the average be dispatched in both directions eight trains daily upon single lines, and upon lines double throughout, twelve trains, besides a few for the service of the railway and the post, as well as for commissariat stores. Were the goods trains entirely discontinued, and the trains for the traffic of the line reduced to a minimum, and regulated conformably to the military time table, as many as ten trains could daily be dispatched on single lines, and fourteen on lines double throughout.

It is recommended to start the trains at intervals of an hour and a half, and in such a manner as to gain the interval of a day which could be employed in compensation for any irregularities occurring during the transport.

In effecting the transport of a large body of troops, requiring about fourteen days for its accomplishment, one or two days of rest on which no troops are embarked, are included on each line. These days are utilized to compensate for irregularities which may arise.

5. There can be carried, as a rule, in a military train, one battalion of 1000 men, or one squadron of 150 horses, or one battery of six pieces, or three-fourths of an ammunition or other column, each body of troops being provided with its war equipment, the train not numbering less than sixty axles, nor much over 100 axles in strength. According to this scale is regulated also, the distribution of the staff, the pontoon column, the divisions of the train, and the administration. On an average there can be carried per axle, sixteen men, or three to four horses with one to two horse-holders, or $\frac{7}{8}$ to $\frac{3}{4}$ of a carriage.

Commissariat stores are most satisfactorily forwarded by being attached in one or more wagons to the troop trains during intervals in the troop transport. Definite arrangements for these stores can hardly be effected with the necessary precision beforehand, and freedom in the movement is desirable. By this method moreover special escorts are saved.

It is accordingly the duty of the Intendantur to place itself in proper time in communication with the Line-commission with reference to the dispatch of commissariat stores. Should circumstances however make it necessary to transport these stores in trains specially provided for them, such trains must be included in the total number for the day's service, and are to be taken into account in arranging the time tables and dispositions for the journey.

N.B. A store train will carry a day's supply for an army-corps.

6. No wagons may be attached to military trains for traffic of any other kind, with the exception of the wagons for the post, and a few for the use of the Intendantur, or for the forwarding of army *matériel* within the limit laid down in the preceding clause.

7. The average speed of military trains is from three to three and a quarter miles (German) an hour, including the shorter halts.

8. After every eight or nine hours of the journey a halt of from one to two hours duration takes place at a so-called "chief halting place," when refreshment is served to men and horses. The number of these halting places depends on the length of the lines, their choice partly on locality, partly on the means of refreshment existing in their vicinity.

9. Infantry must be ready at the point of embarkation an hour before the time of departure; the baggage of the same two hours; cavalry and artillery also two hours; columns, train, &c. as much as three hours before. If a detachment cannot proceed at its allotted time, or if it is delayed *en route*, it must, except under special circumstances, wait until the next blank-day on the line, unless it can be forwarded without causing inconvenience to succeeding trains.

From six to twelve hours are necessary for the loading of a train with commissariat stores.

10. In order to simplify the train arrangements and lighten the superintendence, the loading and unloading should be centralized at main points predetermined. The choice of these stations is governed by considerations partly of a military, partly of a technical nature, as well as by local conditions.

11. Special regulations are issued at the outset by the department of Military Economy, on the refreshment of the troops during the halts in the journey. Means of refreshment are provided at the principal halting places partly by the State, partly by suttlers, possibly also by the supply of rations to the men.

12. In addition to the ordinary provision made during times of peace for the transport of troops, there must be provided at the chief halting places—a covered space to afford shelter from the weather; a small hospital to receive the sick who cannot proceed on their journey; a supply of water, and latrines at a suitable distance.

13. The oats for feeding the horses on halting is carried with the troops; the hay, unless carried in covered wagons, is received from the stores established at the halting places; straw (as far as is required for strewing upon the loading ramps) is obtained before starting, and water is held in readiness at the points of halting.

14. The proper succession and order of march of the troops are regulated, agreeably to the principles enunciated in the foregoing, by means of:—

(1) "A Route and March Table" for each army corps.
(2) "A Military Time Table," and
(3) "A Table of Dispositions for the journey" for each line.

15. The "Route and March Tables" are prepared by delegates from the Staff, in accordance with directions issued by the War Minister regulating the time when the several corps are to hold themselves in readiness to march, as well as in accordance with general principles relating to transport, having regard to the importance of the greatest possible speed in effecting the concentration, and to the working powers of the lines. These tables are submitted to the War Minister directly by the Central Commission (Cl. 18) and afterwards communicated by the former to the General Officers in command. Alterations in these tables when once approved are strictly prohibited, unless under special circumstances, when the case must be referred in proper time to the War Minister.

The "Route and March Tables" contain:—

(1) The place of mobilization, day of readiness to march, and numerical strength of each detachment.

(2) The day of departure by train, and the stations of departure and arrival.

The hour of departure, as well as the day and hour of arrival are included in the "Table of Dispositions" for the journey.

(3) The composition of the successive detachments to be dispatched daily.

16. The "Military Time Tables" are drawn up similarly to the ordinary time tables of the lines, which they supersede during the continuation of the transport. They regulate the arrival and crossing of trains both military and others in both directions. The military trains for each day's transport are marked with Roman numerals.

17. A table shewing the dispositions for the journey is prepared for each line on the basis of the "Route and March Table" and the "Military Time Table," and assigns the force detailed for each day's traffic in the former to the trains specified for that day in the latter.

In this table is included the hour of departure of each detachment, the arrivals at the places of repose, and the names of the stations selected for the refreshment of the troops, and the day and hour of arrival at the point of debarkation.

Troop trains travelling in concert on a line receive successive numbers, which afford later the requisite means of checking the accounts, and clearing up points which call for enquiry.*

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* The officer in command of troops transported by train delivers vouchers for the troops conveyed, shewing the successive numbers of the trains, to the station superintendents at the points of embarkation and debarkation, and on these the claims of the railway administration for subsequent payment are based.

SECTION II.

Conducting, and Superintending Authorities.

18. In carrying out a concentration of Prussian forces on a large scale by railway, the following departments of State are concerned:—

(1) The Ministry of Commerce, Trade, and Public Works.
(2) The Ministry of the Interior.
(3) The War Ministry.
(4) The Staff of the Army.

Deputies from these departments make the arrangements for the transport of the forces in accordance with the instructions they receive from their respective heads. The deputies form a

Central Commission

composed of a superior officer as president, an officer of the War Department, an officer of the staff, an official of the department of Military Economy, one or two officials of the Ministry of Commerce, and one of the Ministry of the Interior.

The seat of the Central Commission is in Berlin. The members are nominated during peace, and can at any time be assembled. The heads of departments keep each other informed of any changes in the composition of the commission. They furnish their deputies with instructions and receive information from them of the results of the meetings which are appointed by the president. In peace time the duty of the Commission is to consider such changes as may be necessary in the regulations for the ordinary transport of troops by rail. When war threatens the first duty of the commission is to test the Route and March Tables proposed by the staff, in their relations to the technical conditions of railways. The Line commissions, which are called into activity in the event of war, and the railway administrations on which devolve the disposition of the rolling stock, &c. on the lines included in the Tables, are next appointed. The chief halting stations are selected; special instructions for the several members of the Route commissions are drawn up, and all other questions of detail which present themselves discussed and settled.

19. Two members of the Central Commission, namely an officer of the staff, and an official of the Ministry of Commerce form a special Executive Commission.

These two members, acting in concert, order and direct the measures to be carried out for the troop-transport in accordance with the decisions of the Central Commission. Each member represents especially the interests of his own department and keeps the other currently informed of what occurs in it.

20. As soon as the Route and March tables are examined and approved, and the chief halting places determined, the Line and Route commissions required for the operations, and for which the requisite staff has already been named during peace, are called into activity.

21. When the concentration has been effected, the dispositions are entirely directed by the executive commission for the purposes of the operating army, the resources of the railways lying both within and without the frontiers being called into requisition. On this account the executive commission is attached to the chief head-quarters, and as a rule follows it.

Line Commission.

22. Since the transport of large bodies of troops usually requires the similtaneous employment of several main lines of rail, the efficient superintendence of the whole is beyond the power of the executive commission. For this reason a Line commission composed of an officer of the staff and a superior railway official is formed for each line taken up. The duty of these commissions is to direct the transport over their respective railways, under the superintendence, and agreeably to the instructions of the executive commission.

23. The Line commissions direct their attention especially to the following points:—

(1) That the transport of the troops is carried out according to the "Instructions."

(2) That the requisite preparations are made for loading and clearing the trains, and for the accommodation of the troops, at the points of departure, arrival, and repose.

(3) That the trains are in good condition and ready at the right time and in proper order to receive their contingents, according to the dispositions predetermined for the journey; and that they are provided with the necessary staff of railway servants.

(4) That the proper interval be preserved between the trains, for which the Route commissions at the various stations are chiefly responsible.

For the attainment of these objects the constitution of the Line commission is regulated as follows:—

Each Line commission co-operates with the agent of the railway administration of its line. They estimate the amount of rolling stock required to carry out the train service in accordance with Route and March tables; determine the station of arrangement, and draw up the military time table for the line. When this has been done, the Line commissioners arrange the journey-dispositions in such a manner as to avoid as far as practicable the departure and arrival of cavalry, artillery, and pioneer trains at night. The journey dispositions are then examined by the executive commission and submitted for the approval of the central commission. They are then communicated through the different departments to the Route commissions, the agents of the railway administrations, and the generals commanding, and by the latter transmitted to the different corps.

The necessary arrangements are made with the railway authorities for the construction of temporary ramps, &c., and especially for sending the quarter-masters in advance of the troops, which can generally be done by the troop trains of the day before, and in exceptional cases by the ordinary passenger trains. Should the rolling stock on a line be insufficient for the transport, the defficiency is supplied by the executive commission, which draws on the stock of other lines.

24. It is the duty of the Line commissioners to carry out the dispositions at the several points of the line. An inspection of the line is made when practicable a few days before the commencement of the transport, to test the sufficiency of the arrangements and supplement any deficiencies found to exist.

25. Shortly before the commencement of the transport, the Line commissioners establish themselves at a certain point on their line determined by the central commission, preferably at the chief point of embarkation. The troops about to travel on the line are apprized of the place which has been selected. At this point early intimation of the whereabouts of the Line commissioners must be given, should their presence be required temporarily at any other point on the line. On the completion of the concentration, the railways, both those which circulate within the kingdom and foreign lines which may have been occupied and put into working order are employed during the operations as lines of communication in rear of the army, and for the transport requirements of the forces both to front and rear. This transport service is likewise directed by Line commissions, those acting during the concentration retaining their functions, or new commissions being appointed, should a re-consideration of the whole railway system be found advisable by the executive commission.

In general, a Line commission is allotted to each army or corps operating independently, and takes its post either at head-quarters or at some point answering the same purpose. These railway commissions serve as the channels by which the requisitions of the executive commission on the one hand and of the military commanders on the other are communicated to the railway administrations.

Route Commissions.

26. This name is borne by the commissions appointed for the purpose of exercising superintendence at the loading, unloading, and halting stations.

At the loading and unloading stations they are composed of a staff officer, as route commandant, with a subaltern officer as assistant, an officer of the Intendantur, with an assistant, and a government official. On railways lying beyond the frontier the latter is replaced by a representative of the government of the country occupied.

27. During peace the required staff is nominated by the departments concerned for such places as are likely to be used as stations of embarkation, debarkation, and repose. The actual appointment of the Route commandants and their lieutenants, for which qualified Landwehr and retired officers can be selected, is made on the outbreak of war, by the general in whose command the station of the Route commission lies, and is by him notified direct to the ministry of war and the executive commission.

28. As a rule the members of these commissions are in direct communication with their respective departments, and are alone responsible to them. The route commandant or his lieutenant must however be kept informed by the other members of the various arrangements.

29. The following may be said as regards their functions in general:—

(1) The Route commission is apprized by the Line commission of the daily arrivals, departures, and halts of trains along its route, as well as of the order of the trains, their number, and composition agreeably to the journey dispositions.

(2) The Route commandants or their lieutenants occupy, at their posts, as regards the transport of the troops, the position in all respects of the commandant of a place, so that they alone are responsible for the maintenance of discipline at the several points, and it is to be enforced by them alone. In order to carry out this duty, they are to receive the assistance and co-operation of the officers commanding troops, or of the commandants of places. All correspondence with railway and government officials relative to the maintenance and transport of men and horses is carried on exclusively by the Route commissions, and the commanding officers of troops are enjoined, without regard to their rank, to conform strictly to the instructions they receive. The Route commandants receive their orders from the central or the Line commissions, communicating with and reporting to them. Disciplinary power over the troops is not delegated to the Route commandants, but officers in command are bound to take cognizance of their representations, should the arrangements be obstructed by the military.

(3) Officers commanding detachments and corps are to inform the Route commandants of the time when they will arrive for embarkation, in order that the requisite preparations for their reception may be made.

(4) The government officers or the Route commissions at the chief points of embarkation and debarkation will be the channel of communication for the maintenance of the police arrangements, and for all requisitions on the authorities, as regards the provision of temporary shelter, food, and forage, for men and horses, as well as the establishment of communications beyond the railway stations, &c.

(5) The commissariat officer attached to the Route commission carries out the requisitions of the Route commandant, as regards the number of rations, &c. required for the troops. He is, however, in other respects subject to instructions emanating from the department of military economy.

(6) The railway official on the Route commission acts independently in all technical matters, bearing on the transport, the loading, unloading, and marshaling of trains, as well as with regard to the employment of the railway servants, the utilizing of the telegraphs, rolling stock, &c. He receives his orders from the railway official of the Line commission, to which his commission is subordinate. He keeps the Route commandant fully apprized of all arrangements, and acts in complete accord with him.

(7) The Route commandant makes requisitions on the commandant of the nearest garrison for all clerks, non-commissioned officers, and orderlies he may want. The number of this staff depends on the duties to be performed on each occasion. The staff of railway servants required by the railway official on the commission is obtained by that official from the railway authorities.

30. While on the one hand the Route commandants are empowered to give instructions to the officers in command of troops, even of higher rank, as regards the maintenance of the troops before and during the embarkation, on the other hand it is incumbent on them to adhere to the dispositions for the transport laid down by the military staff officers of the Line or Executive commissions.

31. In all matters of a pressing nature, referring to the troop-transport, correspondence is carried on by means of the state and railway telegraphs.

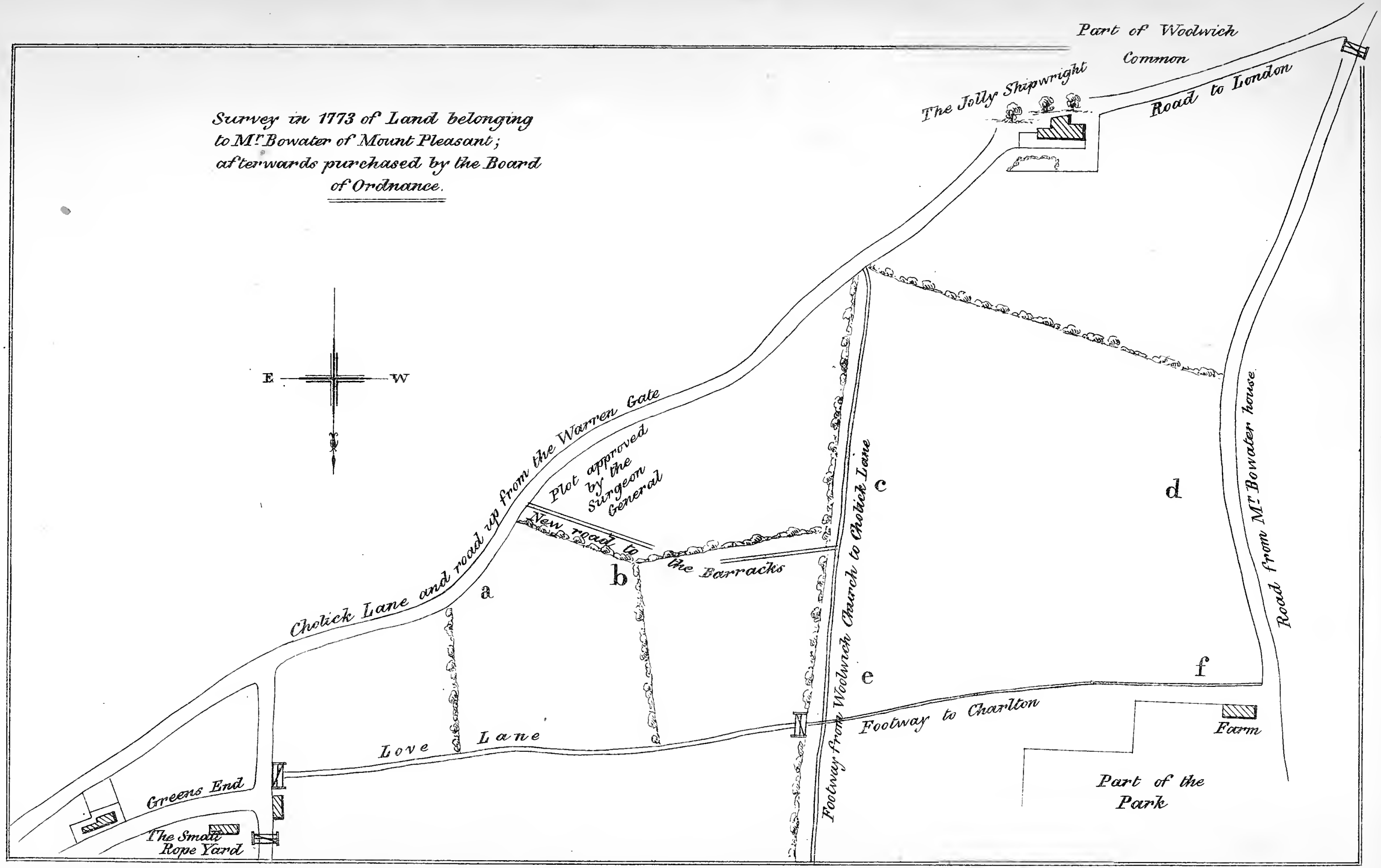
The portion of the general regulations which is contained in these pages bears date, Berlin, May 1, 1861, *and is signed by the Minister of Commerce, the Minister of the Interior, and the Minister of War and Marine.*

OLD WOOLWICH.

BY J. HEWITT, Esq.

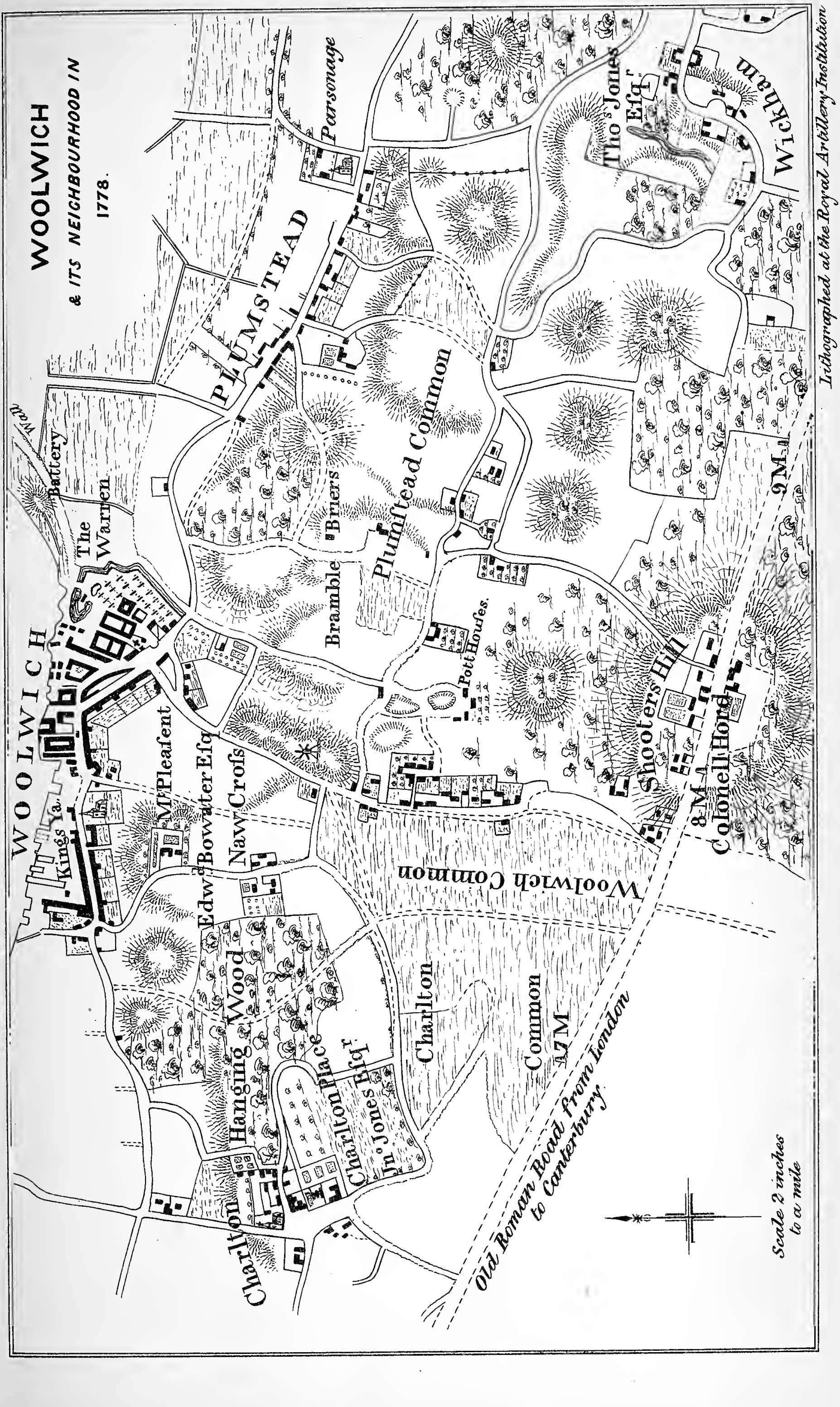
Woolwich may be regarded as the *Alma Mater* of "the Royal Regiment," and many a time, on the burning plains of India or amid the snows of Canada must the remembrance of the pleasant walks of Shooters' Hill, the breezy banks of the Thames, and the green slopes of Eltham and Erith have stolen-in to break the weary monotony of camp or barrack life. And to how many of those who, now grown men, have passed their early years in this neighbourhood, would the Woolwich of to-day be a puzzle and a mystery! The street upon street, the extension of dockyard and arsenal, the old roads stopped, the new opened, churches, hospitals, piers erected, railways piercing the hills, steamboats crowding the river; these and a hundred other changes would meet their gaze on every side, and almost lead to the belief that they had been realizing the sleep of Sleepy Hollow.

No place in England perhaps has more rapidly changed than Woolwich. The converse of what one sees at the Christie Museum, one sees here. There, we wonder to find men's works of 100,000 years old so like what we still see before us; here, we marvel to observe how completely a poor hundred years has changed everything around. Woolwich in 1770–80 has scarcely a feature of the Woolwich of to-day. Let us look at the Maps of that time. First the Survey of 1773. This is very curious, for it shows us that the road to London in that day was very different from our modern notions of Londonwards. The traveller proceeded from the Arsenal Gate up what is now Mill Lane (see the mill itself in map of 1778), at the top of which we find a convenient baiting-house (after such a long journey), the "Jolly Shipwright." Mill Lane was then, we see, called Cholick Lane. This seems to be the old Anglo-Saxon name, from *Ceol*, a ship, and *wic*, locus; the Ship-place or Ship-houses. Chelsea derives its name in a similar way: see Bosworth's Ang. Sax. Dictionary, in voce. From the tavern the London Road turns to the right, having the Common on the south, and the open fields (now the Barrack Field) on the north. I ought before to have mentioned that this Survey of 1773 was made for the Board of Ordnance, and comprised lands belonging to Mr Bowater, who resided at Mount Pleasant, a mansion with park, occupying the site of the present Royal Marine Hospital.—See Map of 1778. In that map also we find the "Jolly Shipwright" (over-against the windmill), and further trace the London road. It ran westerly, by the Duke of York's Cottages (the old roadside oaks yet in being), then along the Charlton Park wall to the lodge gate, through that gate (though no gate there at that time), then turning to the right, along the lane (still existing in picturesque ruin) almost to the



Survey in 1773 of Land belonging to Mr. Bowater of Mount Pleasant; afterwards purchased by the Board of Ordnance.

Lithographed at the Royal Artillery Institution



WOOLWICH & ITS NEIGHBOURHOOD IN 1778.

Lithographed at the Royal Artillery Institution

stables of Charlton House: there it bends to the left and runs in a S.W. direction along another fine old lane to the park gate in Marlborough Lane, and so on to the Shooters'-Hill-Road, the ancient Watling Street, which it followed to London.

The Duke of York's Cottages which we have mentioned were built in replacement of a number of mud huts which had been run-up by soldiers who did not like Barrack quarters. An old inhabitant of the neighbourhood states that he well remembers these mud huts, that they reached far up the Common, that there were "several hundreds of them," the soldiers when ordered on foreign service making them over to new comers; but "at last, the Government growing ashamed of them, had them all pulled down and the present huts built in their stead." Be it observed, the new buildings are still always popularly called "the Huts."

Reverting to the Survey of 1773, it will be noticed that the foot road to Charlton passes along a narrow lane called "Love Lane," and is then continued by a field-path to Mr Bowater's farm. Love Lane is still traceable: opening at one extremity into Green's End, terminated at the other by a gate near St John's Church. The "farm" occupies the corner of Mount Pleasant Park, and is now represented by the Telegraph Office in Artillery Place. Artillery Place itself lies along the line of the old field-path to Charlton. Another footway cuts this at right angles, leading from the old church to "Cholick Lane" and the Common. The "Plot approved by the Surgeon-General" is where the Hospital was afterwards erected, but the "new road made to the Barracks" does not quite accord with the present road, which is more to the north (*a* to *b*). The letters *c, d, e, f* indicate pretty nearly the site of the present Royal Artillery Barracks. These letters, *a* to *f*, are all that have been added to this map. The original plan is five times the size of the copy here given. I must add that neither this nor the Survey of 1778 register very accurately with the Ordnance Maps of our own day.

The R.A. Hospital named above was completed in 1780. "April 8, 1780. The new Hospital opened on Monday last on Woolwich Common for the reception of patients is calculated to hold 200 beds."—(Old newspaper). About 1806 a second hospital was added, "to accomodate 700 men."—(Brayley, Hist. of Kent, p. 537). So that the "new Hospital" of the preceding paragraph became "the Old."

Turning now to the map of 1778, extracted from the Survey of Kent in 25 sheets, by Andrews and Drury, we find many curious points for consideration. "Mount Pleasant" is conspicuous; now replaced, as we have seen, by the Royal Marine Hospital. "Naw Cross" is to the south, a mis-spelling perhaps for New Cross, but I have not been able to discover anything relating to this locality beyond the patent fact that it must have been included in the present Barrack Field.

To the west is the "Hanging Wood," a noted place for robberies in the "good old times." Every one acquainted with the fine, aged trees in the grounds of the Royal Military Repository, the oaks, thorns and birches that there abound, will readily recognise this spot as a striking memorial of the original wood. The boundaries, as set forth in the map and carefully traced on the spot, may be stated as follows:—Beginning at the toll-gate on the Greenwich Road, we pursue that road eastward to within about a hundred yards of the "Lord Howick" tavern, which stands at the S.W. corner of the Dock Yard. Then, with a sweep to the S.E., passing by the railroad foot-bridge and the top of Prospect Place, we approach the west corner of the Marine Barracks, overpassing Godfrey Street a few yards. From this point we make a straight line, taking in the oak trees of the garden of "Rose Mount" (east of Pelliper Road), over the "Green Hill" to the Observatory. From here another straight line runs to about the middle of the wall of Charlton Cemetery: a bend to the N.W. now brings us to the corner of Charlton Park: then along the high-road to Charlton village, round the "Fair Field," by St Paul's church, along the bank of great trees running first northward and then more to the east, and finally striking the Greenwich road at or near the toll-gate from which we started. Within this boundary will still be found in many places old trees which formed part of the wood, and some names yet subsist which recall the nature of the ground, as Wood Street, Woodland Terrace, the Woodman, &c. A road, it will be seen, winds through the Hanging Wood from Woolwich Common to the Greenwich highway. This, I think, passed by the "South-west-Gate Guard" to Little Heath, on to Upper Woodland Terrace, and thence between the two hills figured on the map, of which the most eastward is now covered with houses, embracing Trafalgar Street, Prospect Place, &c., and the other still in its original form of a grassy knoll.

From the old newspapers of the last century we gather many notices of depredations in and about Hanging Wood. A series of paragraphs relating to Woolwich, collected from the public journals from 1690 to 1844, and now deposited in the British Museum, is a fruitful source of such relations and of every kind of news regarding this locality.* Under 1732 we read: "On Sunday morning the Rev. Mr Richardson, going from Lewisham to preach at Woolwich, was attacked by a foot-pad in Hanging Wood, who robbed him of a guinea, leaving him but two-pence, and then made off."—(fol. 1). In January 1762: "Several people have been robbed this week in Hanging Wood near Woolwich."—(fol. 1vo.) 1782: "Three men robbed a Boatswain of a man-of-war, near Hanging Wood, of his watch and ten guineas, but some gentlemen coming up, they took to the Wood," &c. (fol. 3). 1812: "On Tuesday last a poor boy was murdered in a wood near Woolwich by a ruffian who, having robbed his master and being pursued, fled for refuge to the wood, where being seen by the boy, the latter screamed with terror of him, on which the villain seized and strangled him."—(fol. 4).

The cliff which runs from the top of Upper Woodland Terrace in a N.W. direction is very full of fossils. The deposit overlies the Sand bed. Examples of the shells &c. found here and in the neighbourhood, including those of the Chalk, may be seen at the Geological Museum in Jermyn Street or in the Museum of the Royal Artillery Institution. Much valuable information on the subject is contained in the 4th Vol. of the Transactions of the Geological Society, by Dr Buckland and others. Mylne's Geological Map of the neighbourhood of London should also be consulted.

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* Press mark, "579, l. 19, Newspaper Paragraphs relating to Woolwich: folio." As we shall often have to quote from this volume, we will for brevity use the initials "N.P.," adding the folio.

At the top of this cliff, in the pasture known as "Whitehouse Field," are appearances of an ancient camp. My late friend, Colonel Dundas, held with strong conviction that it was a Roman intrenchment. Whether Roman or Celtic, there certainly do appear great indications of a fortified work. Now that we are on the spot, we may add that the locality is interesting also in its botanical aspect. Hasted (Hist. of Kent) tells us:—"The gravel pits at Woolwich have been for many years the common place for simpling among the apothecaries and druggists of London." And, *apropos* of Roman works, the large camp at Barking, with its curious Specula, is well deserving the short walk it involves.

Returning to our Map: Woolwich Common and Charlton Common appear to the south, the latter being the more extensive; and it may be remarked that it is still a disapproved fact among the Charltonians that the minority should have carried the day in the matter of naming the whole expanse. It should have been called "Charlton Common," they say. The road running along the east edge of the common must not be confounded with the present road passing by the Reservoir: it is that now named Lion Lane. Parallel to it eastward is Shrewsbury Lane and its continuation, Plum Lane. By this name of Plum Lane and the analogous one of Plumstead, may it not be assumed that the Plum was the staple fruit of this neighbourhood, as the Apple and Cherry now are in the Maidstone district? The Pottery (or "Pott Houses" of the map) has disappeared within the last dozen years. It stood within the angle of the present Herbert Road, Ripon Road, and Eglinton Road. The little wood above it was famous for its nightingales, and the ceramic proprietor of the spot for his surly deportment towards any poetically-disposed intruder on his land.

Shooters' Hill, it will be seen, is surrounded by woods and copses. It was this advantage of covert which made the spot so pleasant to highwaymen. To recount the many sensational deeds that have illustrated this locality would require a volume. Indeed, it is strange that a volume has *not* been written on a subject so congenial with the feelings of modern writers and modern readers. We are not without the hope of yet seeing the popular *drame* of "Shooters' Hill," in five acts and fifteen *tableaux*, including of course Woolwich Common by moonlight, the Robbers' Parlour at the "Jolly Shipwright," and the chamber of Annette at the "Fox under the Hill." By the bye, this Fox-under-the-hill was a little public-house at the foot of Shooters' Hill, where the road to Eltham turns off. When the more aspiring "Lord Moira" tavern appeared, the Fox broke cover and squatted in the dead flat of the London Road, a mile further west. Hence the present misnomer.

On the top of the Hill was formerly a Beacon. This beacon, with others leading out eastward, is noticed in Ogilby's Road-book of 1720, and an old villager tells me that he well remembers it, and that it stood on the south side of the road. In the old Accounts of the Churchwardens of Eltham various payments are recorded "for watchinge the beacon on Shutters Hill." My old villager also remembers six men being hanged here for robbery with murder, four on the top of the hill by the waterworks, and two down by the Eltham road. The shooting party of Henry the Eighth at this spot has often been described. If *he* had been hanged (either at the top or bottom of the hill), it would have much redounded to the honour of his age. The old newspapers give us many accounts of adventures on this ground. Under June, 1773 we read that "On Sunday night about 10 o'clock Colonel Craige and his servant were attacked near Shuters Hill by two highwaymen well mounted, who, on the Colonel's declaring he would not be robbed, immediately fired and shot the servant's horse in the shoulder. On this, the footman discharged a pistol and the assailants rode off with great precipitation."—(N.P. fol. 2). Among the more disastrous results of such attacks may be mentioned the finding of a poor fellow, "in a dell of Shooters' Hill Wood," lashed to a tree, and who had apparently died by strangulation. These knights of the road are said to have had a further source of emolument, that of selling passes to such persons as chose to secure the advantage of going and coming unmolested through their territory. Thus, Dr Watson, tutor to the Princess Charlotte, when that princess was residing at Shrewsbury House, obtained from the Shooters' Hill cut-purses the privilege of approaching "the Daughter of England" without having his brains blown out. Shrewsbury House named above is said to have been acquired by gambling—and soon after lost again by the same process. Into the annals of gaming it is hardly worth while to inquire. If the tradition is true, one may almost believe in some maleficent influence dominating Shooters' Hill, where the knights of the pistol on the one side and the knights of the dice-box on the other divided the empire of infamy. Some indeed may be inclined to give the balance of virtue in favour of the highwayman, who at least puts his own life in jeopardy when drawing his pistol upon the belated traveller.

To highwaymen, smugglers succeeded in the possession of Shooters' Hill wood. Cargoes of spirits, tobacco, and tea were brought up here from the river-craft and hidden away among the bushes and fern brakes. The villagers round the winter fire have many a stirring tale to tell of these worthies, not altogether unsympathisingly. On one occasion a country fellow had stumbled upon a deposit of tea in the wood. Joyfully he filled his pockets with the fragrant leaf, a peccadillo which the concealed watchers did not care to notice; but presently our Fortunatus returned with a great sack, and began to fill that. This was too much for the smugglers, who rushed from their hiding-place and belaboured the poor fellow to within an inch of his life.

In 1767 we have a remarkable newspaper notice:—"In the Circle of the new Town to be built on Shooters Hill is to be a Bason of water, and in the centre of that Bason a circular Island, on which a Coffee-house is to be erected, and over it an Assembly Room, the entrance to be by four Bridges, from which there are to be four grand Streets, to be made out for Greenwich, Woolwich, Gravesend, and the High road over Shooters Hill." —(N. P. fol. 1vo.). A few months later, a further notice appears, inviting subscriptions for the purpose of carrying out this notable project, and of course promising wonderful gains to those who may determine to join in the undertaking. In what year this company obtained their winding-up-order, I have not been able to learn. From highwaymen, smuggling, and casinos we come to fortification:—

1837. "Fortifying Shooters' Hill. The military trigonometrical and topographical survey of this hill, in relation to its commanding the approaches to Woolwich and the Royal Arsenal, is now proceeding rapidly; but it is feared that the mercenary demands of the patriotic land-holders will compel the Board of Ordnance to alter the whole plan of the contemplated fortifications."—(N.P. fol. 28vo.)

The building called Severndroog Castle, which is triangular in plan, was erected in commemoration of the capture in 1755 of an Indian fortress of the same name. It has been very handsomely furnished and decorated, and the view of its old painted doors, walls, and cabinets, now perishing with damp and mildew, the tattered Indian armour and weapons covered with rust and cobwebs, affords a melancholy subject of reflection as we mount from stage to stage of this dilapidated belvedere, through stair-cases where the window-sills are covered with thousands of generations of deceased flies and no mean amount of defunct and moribund wasps and bees. But fresh is the view from the summit: all the fresher perhaps from the preliminary decay; and glorious the picture of hill and stream, meadow and woodland, bowery village and gleaming corn-fields. A few years ago, the prospect was for a time still more beautiful, for the Ordnance triangulators had fixed their "crows-nest" on the summit, which gave a wonderful increase of extent to the panorama. On the N.W. side of Shooters' Hill, a little above the Royal Military Academy, is a Mineral Well, celebrated for its curative properties. Queen Anne is said to have used it; and Evelyn, under 1699 writes:—"August: I drank the Shooters Hill waters." The well is now in charge of a Sapper, and still frequently visited by invalids of the neighbourhood.

Of Plumstead Common we have not much to say; but we would point out that the little mound seen about a furlong to the north of the road before it descends to the Woolwich Cemetery gate, and having much the appearance of a disturbed Anglo-Saxon tumulus, was the old practice-butt of the Royal Artillery; when the battery was placed on the west side of the ravine which runs between the old windmill and the "Slade School." Of Plumstead Church we have as little to note, except that it is about the ugliest in England, always of course excluding Woolwich Church and Weedon in Northamptonshire. Woolwich Church, while we are on this unpleasant subject, was built in the reign of George 2nd, under Queen Anne's Act; but it is to be noted that it does not occupy the site of the old church, its predecessor. That building stood on the north side of the present iron-paled way through the churchyard, this footway not being then in existence.

West of Plumstead on our map is "Bramble Briers," a park-surrounded mansion existing not many years ago on the bank overlooking the Thames and the hills of Essex. The name, not being considered euphonical, was changed to "Bramblebury House," and a pleasant place it was; but street-builders and eligible-situation merchants fixed their sordid eyes upon the locality, and even euphony could not save it. The mansion itself was converted into the vicarage-house of a new church, the park laid out in streets and terraces; and this will explain how we come to have a row of houses bearing the odd name of "Vicarage Park." The old windmill seen to the west was standing in the memory of many living inhabitants. Its place was on the east side of the road still called Mill Lane, a little above the Garrison Church. A second windmill, named in surveys "the New Mill," stood in the field behind the residence of the Commandant.

Of the Town of Woolwich, so far as regards its buildings, we have nothing very interesting to record. The place, however, is of great antiquity. In Domesday Survey it is called Hulviz; in the *Textus Roffensis*, Wlewic; in 1044 it is Wulewick; in the 14th century Wolwiche: and in the 16th century Wolwych. The most acute historians have failed in determining its etymology.* A few of its old half-timbered houses may still be found in obscure bye-streets, as in "Nile Street" (whilom "Hog Lane") and in the portion of High Street near the Arsenal wall. They are, however, of the very humblest character. In Cannon Row is yet seen the Hospital founded in Queen Elizabeth's time by Sir Martin Bowes, Lord Mayor of London, as an "Alms-house for five poor Folk." The present structure is a re-erection of 1771. In our map of 1778 will be seen a block of building in the form of a bow and its string. That is the old Rope Yard, where in earlier days the Cables for the Royal Navy were manufactured. A street called "Rope Yard Rails" still exists on this spot. Continuing the line of the bowstring towards the river, we impinge on the old Market-place, where the Gun Wharf was situated previously to its removal to "the Warren."—(Lysons' Env. Vol. IV.; and see MS. 16,946 in Brit. Mus. for plan of this spot). Arrived at the river, we may mention that in the middle-ages the fishery of Woolwich was of considerable value, and Thames salmon was procured here, with various other fish. In 1320 we learn from the ancient Letter Books of the City of London that "Master John le Fisshmongere" and others "produced at the Guild Hall, before the Mayor and Aldermen, sixteen nets called Kidels, taken in the Thames while under the charge of John de Pelham, fishmonger of Wolwiche, and John Godgrom of Plomstede: who said that the same kidels belonged to certain men of Plumstede, Lesnes, Berkynge and Erhethe, who were there named; and that the said kidels were placed in the water aforesaid, to the destruction of the small fish and salmon, &c. It was therefore adjudged by the said Mayor and Aldermen that the kidels should be burnt, and that the said fishmongers, on the peril which awaits them, should not commit the like offence again."—(Riley's Memorials of London, p. 135). The lawful measure of the meshes of Thames nets at this time was "two inches from one knot to the next nearest knot."

Of the Old Church we have already had some notice. The town contains also several new churches; and, like all manufacturing places, a variety of Dissenters' Chapels, to which star-preachers from London are often invited, to repair the funds of the establishments. The writer once heard Mr Spurgeon preach at one of these meetings. It was soon after the opening of the railway, and of course he "improved the occasion." The reverend gentlemen pictured the competition there would be at the latter day for the best rewards of Heaven, even among those who had done but little here below to deserve them. But vain, my brethren, vain to crush and to clamour! you must produce your *claims;* for there, at the Gate of Heaven, you will find Saint Peter, whose cry will be "Show your tickets—show your tickets!"

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* ? Wold-wic.

Among the more romantic incidents revealed to us by the Newspaper Paragraphs before mentioned, we find, about the year 1770: "Taken away by violence from her friends at Woolwich, by breaking open the locks of her chamber and parlour doors, and forcing her out of a window, MARY BAKER: she is not 15 years old, has a speck in each eye, dressed in an old linen bed-gown, with no stays on, a light-coloured quilted petticoat, and a red cloak, under the pretence of an arrest for a debt, by John Davis. . . And supposed to be concealed by John Spencer, about 13 years old, son-in-law of the said John Davis. This is to caution all persons not to secrete or harbour the said Mary Baker, all clergymen are desired not to marry them, and all inn-keepers and stable-keepers are not to furnish such persons with post-chaises or carriages. Whoever will bring the young Lady unmarried to Cuthbert Andrews at his Majesty's Rope Yard at Woolwich will receive 20 guineas reward."—(N. P. fol. 2.) Under 1769 we read: "Yesterday morning was married at Woolwich George Bond Esquire to Miss Norris of Woolwich, an agreeable young Lady with a genteel Fortune."—(fol. 2.)

Some curious views of old streets and buildings in Woolwich will be found in Roy. MS., 16945—6, and in 579, l, 15, a Collection of Prints; both in the British Museum.

The Warren, now the Royal Arsenal,* was formerly the head-quarters of the Regiment of Artillery, but being found too restricted for the requirements of the service, "a piece of ground of about 50 acres was taken on lease by Government of Mr Bowater (our old friend of Mount Pleasant) about twenty years ago (1775) and spacious Barracks built for the accommodation of the regiment."—(Lysons, Vol. IV.). What was thus built in 1775 was the eastern half of the present structure. At the beginning of the present century, enlargement being required, the architect, judiciously abstaining from all eccentric excrescences by which his "genius" might be manifested, simply repeated on the west side what he already found on the east, breaking the line of the two wings by a goodly central archway of stone. The east gate and west gate bear the seals of these varying dates. On the east gate are seen in full relief the arms of the Duke of Richmond, Master-General at the time of completion of this portion: over the west gate appear the arms of the Earl of Chatham, Master-General in 1806. "On the Parade in front," says Brayley in his Hist. of Kent, "the soldiers are frequently exercised in throwing Shells, for which the open space on the Common (? Barrack Field) affords sufficient room."—(p. 537, A.D. 1806). The same volume tells us: "On the west side of the Barracks is a piece of water where experiments with gun-boats &c. are occasionally made: a new road from this quarter towards Charlton has been just opened."—(p. 537). This new road, opened in 1806, is the one leading by the Woodman and Little Heath to the village. Many interesting old Plans of the Royal Mil. Repository grounds, including the "piece of water" named above, will be found in the Office of that Department.

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* We purposely forbear from noticing at any length the history of the Royal Arsenal, knowing that Lieut. Grover has undertaken this subject, and feeling assured that it will receive at his hands the most complete and satisfactory elucidation.

Of the "King's Yard," as it is named in our map of 1778, we forbear to attempt any special history, from the space which such a history would demand. To those, however, who may feel an interest in the old aspect of this locality, we would recommend an inspection of the very curious volume in the British Museum, Royal MS. 43, a Survey of English Dockyards in 1698.

As we see by a glance at our maps of 1773 and 1778, the present Royal Marine Barracks and Hospital occupy the site of Mr Bowater's house and park. But previously to the Marines being fixed here, there was a large Brewery established at the more southern portion of the ground. From Lysons and the newspapers of the time we learn that in 1806, "the late Mr Whitby's brewery, with 8 acres of land on the rising ground near the Manor House, has been purchased by Government to convert into Barracks for the Royal Marines." The first establishment of Marines at Woolwich was in 1805. In 1815 their first Hospital was built. The present hospital was opened in October, 1861, occupying the site of the old Manor-house, the "Mount Pleasant" of our map.

The Royal Military Academy was "instituted" by George the 2nd in 1741, and located in "a convenient room at Woolwich Warren;" the object of the establishment being "to form good Officers of Artillery and perfect Engineers." Various regulations were from time to time introduced for the good government and welfare of the students. In April 1757 it is promulgated that "The first Cadet who is found swimming in the Thames shall be taken out naked and put in the Guard-room." Under January 1778: "His Majesty has ordered the Company of Cadets at Woolwich to be augmented from 48 to 100."—(N. P. fol. 2vo.). They were visited by George 3rd in 1805: it was on this visit that the "King's Warren" received by His Majesty's command its new name of "the Royal Arsenal." In 1806, Brayley tells us, "the Military Academy (in the Royal Arsenal) is at present unappropriated, the Cadets having been very recently (in 1805) removed to the new building prepared for their reception on Woolwich Common," (p. 533). The number at the Common in 1807 was 126, but there was a junior class fixed at Great Marlow, and 60 were still at the Arsenal. It is the older part of the present building that was thus opened in 1805, Wyatt being the architect.

The Royal Artillery Museum in the Rotunda had for its nucleus the models and projects of the Congreve family, originally reposited in the Royal Arsenal. The Rotunda itself, erected in Carlton House Gardens in 1814 for the State reception of the Allied Sovereigns, was presented by the Prince Regent, who also contributed a collection of ancient arms and armour, containing many very curious and rare specimens, and a series of models originally gathered and set up in Buckingham House by George the Third. The darkness of the room, however, and the inadequacy of the catalogue, rendered the museum of little value, till by the addition of windows in the roof and a careful revision of the catalogues in 1863–4, and subsequently by several judicious purchases and liberal donations, the whole aspect of the place has been changed and its usefulness fully developed. This good result has been mainly effected by the untiring exertions and assiduous supervision of General Lefroy.

In our map of 1778, Charlton village and park appear on the west. In front of the hall will be observed a wide open space, ranging westward with the church tower, and on the other side with the stables (and, we may add, with the old gateway now found in the middle of the front garden of the hall). This was the original site of the celebrated Horn Fair. It will be remembered that in old days, people had not the opportunity of choosing from 40 or 50 columns of the *Times* where they would supply themselves with any possible commodity, from a steam ship to a phial of Dew of Sahara, conveyed by fleet dromedaries *viâ* Morocco and Wapping to Maddox-street, W.C. It was at the annual fairs that they found the means of replacing the breakages that might have been occasioned by the medieval cat. Thus there were fairs for pottery-ware, fairs for wood-ware, fairs for horn-ware &c. In the *Villare Cantianum,* 1659, Philipott tells us:—"The fair is kept yearly upon Saint Luke's day and called *Horn Fair,* by reason of the plenty of Winding-Horns, and cups, and other vessels of horn, there brought to be sold." The inn at the corner of the old fair-ground still exhibits the sign of a Winding-Horn, though we now call it a Bugle-horn; the article itself being at this day pretty well limited to the hunters of Der Freischütz and Fontainebleau. From Lysons we further learn that the fair was formerly opened by a burlesque procession, which passed from Deptford through Greenwich, each person wearing some ornament of horn on his head. This procession, he adds, has been discontinued since 1786. The old fair ground has been squeezed into the limits of a common turnpike road, by what process I know not; and at present the fair is held in a field at the east end of the village, each Big man and Little woman paying a goodly sum of rental for the privilege of being viewed by an enlightened and philosophical public. Horn is now probably the only material of which it would be difficult to find a supply. The mumming has gradually merged from its pristine funniness (if it ever had any) to screaming vulgarity, and the fair is now, at least in the evenings, a perfect orgie.

The Hall at Charlton was built about 1612 by Sir Adam Newton, who was preceptor of Prince Henry, son of James the First. The ceiling of one of the rooms still exhibits among its decorations the Royal arms and the Ostrich plume of the Prince of Wales. The tomb of Sir Adam may be seen in the north wall of the Church, recording in a long Latin epitaph the particulars of his family status and the honours to which he attained. The Princedom of Wales again at a later period became connected with Charlton. In "the Ambulator" of 1807 we read: "Her Royal Highness Princess of Wales makes Charlton her constant country residence, and is much respected and beloved by the neighbourhood." She lived in the old white house facing the west front of St Paul's Church. On the west side of Charlton Park is a fine old avenue of trees, the east end facing the hall stables, the west approaching Marlborough Lane. This was the entrance to the old Rectory house of the parish, which stood at the west end of the avenue. Near the south angle of the Park will be found a large hollow thicket, forming, before the trees were grown, a sort of amphitheatre. Here bull-baiting was practised, and the spot still bears the name of "the Bull Pits." My "old villager" tells me that, when the sport was stopped here, the bull was baited at the corner of the Eltham road, where the Herbert Hospital now is.

At the N.E. corner of our map of 1778 will be seen a small portion of the Thames river-wall. This wonderful work, now generally attributed to the Romans, may be well studied in the marshes hereabout; but to have an adequate conception of its extent and importance, a careful examination should be made of the Ordnance Maps from Greenwich to Thames mouth, including the Medway and the various creeks and streams on both banks. Roman temples and Roman amphitheatres sink into utter insignificance in comparison with this gigantic tide-barrier.

Woolwich,
Dec. 24, 1868.

THE

FIELD ARTILLERY OF THE GREAT REBELLION;

ITS NATURE AND USE.

BY LIEUTENANT H. W. L. HIME, R.A.

The nature and use of Field Artillery during the civil wars of Charles I. is a subject that has seldom attracted the attention of military writers, and it has generally been disposed of in a single sentence by those who have chanced to notice it. Yet it is a subject to which great interest is attached, for to these civil wars may be traced the origin and rise of Field Artillery, properly so called, in England; and the chrysalis bears no closer connexion to the butterfly than the Artillery of the Great Rebellion to the Royal Regiment of Artillery. There may be satisfactory reasons for commencing the history of the Regiment with the Company formation of 1693 and the Regimental Train of 1698, but such a history is but a chapter, however long and important a chapter, in the history of Artillery in England. Each phase of the existence of the British Artillery is a higher development of the preceding one, and to fully understand the state of the Ordnance and the manner in which it was used towards the close of the 18th century, it is necessary to go back a step and examine its condition in the middle of the century. To conclude that the origin of a standing force of Artillery dates from 1693, because the history of the Regiment begins at this year, would be a most serious mistake.

> "Vixere fortes ante Agamemnona
> Multi . . . ."

There were gunners before General Borgard, and in point of antiquity as an established force the English artillery precedes the cavalry and the infantry. Clouds and darkness envelop the birth and infancy of a corps whose history stretches back into the dim twilight of the 14th century, but although it may be true that the yeoman of the guard, hitherto regarded as the most ancient military body in England, were formed by Henry VII. in 1485, it is no less true that we find traces of a standing force of artillery even at this remote period,—" a kind of regular troops, chiefly accustomed to the use of artillery, . . . maintained at the very few places where it was thought necessary or practicable to keep up the show of defence.*

The artillery, field and siege, of the middle of the 17th century was in a backward and neglected state, and it cannot be looked on as an arm of the service but merely as an auxiliary, and a feeble one, to the cavalry and infantry of an army. After three years fighting so little importance did Charles I. attach to his field guns that in the plan he caused to be drawn out of the battle of Naseby, no place is assigned to them, and judging only from this plan one would suppose that no artillery was used in the battle.† The siege artillery, too, must have been mean indeed against which private houses, not very strongly fortified, could hold out for weeks and months.‡ Lathom House, garrisoned by 300 men and armed with 8 guns, successfully resisted 2000 besiegers with a train of artillery for nearly three months, and Basing House was in a state of almost continuous siege for two years, and was only taken at last by Cromwell in person. The impotence of the artillery was due to the total absence of artillery officers, the scarcity of trained artillerymen, the wretched construction of the carriages, and the badness of the gunpowder and ammunition; for the guns in themselves were not very far behind those in use at the outbreak of the Peninsular War. "Any one who examines the old guns in the Tower of London, or in the Museum of Artillery at Woolwich may see that they are of the same genus as modern smooth-bores, and even notice some specimens quite as soundly and as artistically cast as any of those of the present century; nay more, he may infer that our modern cast guns can scarcely be superior to their prototypes in range power, or susceptibility to rifling."§ Add to these causes that the importance of mobility, too little appreciated in the 19th century, had only been recognised by one man in the 17th century, Gustavus Adolphus, and he was, as a gunner, a century in advance of his age.

Of the state of artillery when the Great Rebellion broke out we have full particulars in two books that have come down to us:—

"The Gunner, shewing the whole practice of Artillery; by Robert Norton, one of his Majesties Gunners and Enginiers; London, 1628."

"The Gunner's Glasse; by William Eldred, sometimes master gunner of Dover Castle; London, 1646."

These books contain tables which often differ in the dimensions, weights, charges, and ranges of the guns they relate to; but the writers were evidently painstaking men, and they no doubt give, as correctly as the careless and inaccurate printers of the day would allow them to give, the details of the guns they actually practised with, the imperfections in the construction of their ordnance being sufficient to explain away many discrepancies. There are other old works on artillery extant, such as Smith's "Art of Gunnery," 1600, black letter; Browne's "Art of Shooting Great Ordnance," 1643; and Binning's "Light to the Art of Gunnery," 1689,

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* Hallam's "Constitutional Hist. of England," Vol. II. p. 131.

† Warburton's "Prince Rupert and the Cavaliers," Vol. III. p. 103.

‡ Sir S. Scott's "History of the British Army."

§ Captain Stoney, R.A., see p. 90.

but little is said in these books that is not better said in Norton and Eldred.

The following table is compiled from the tables of Norton and Eldred, compared together:—

Name of gun.	Weight of shot.	Charge, (corned powder).	Charge, (serpentine powder).	Length of gun.	Weight of gun.	Diameter of bore.	Windage.	Length of cartridge.	Metal of gun.
	lbs.	lbs.	lbs.	ft.	cwt.	in.	in.	in.	
Canon Royall	63	27	40	12	71·5	8	·25	—	Iron.
Whole Canon	47	18	34	11	62·1	7	″	—	″
Demy Canon	27	16	25	10	53·5	6	″	—	″
Whole Culvering......	15	12	18	11	41·	5	″	19	″
Demy Culvering	9	6	9	10	22·3	4·5	″	17	Brass
Saker and Drake......	5	4	5	9	14·3	3·5	″	10	″
Minion	3·7	3	3·5	8	10·7	3	″	″	″
Falcon	2·5	2	2·5	7	6·2	2·7	″	7	″

In addition to the above there was a legion of guns, great and small, called after monsters, birds, and reptiles,—such as dragons, basilisks,* sparrows, and rabinets,—but they were of little account and are seldom mentioned in the histories of the time. The guns chiefly used in the field were demi-culverings, minions, and drakes. Norton makes the whole cannon a 39-pr. and the demi-canon a 30-pr. I have followed Eldred, because I believe him to be in general the most accurate writer of the two. He says, "the weight of mettal may differ much," but so serious a discrepancy can only be accounted for by the carelessness of the printers, a fair sample of whose blunders may be seen in the paging of the books in question. All the guns of the time were highly ornamented, and the specimens that still remain are handsome pieces of ordnance. Their extreme length and consequently great weight were caused by the badness of the slow-burning powder, and necessitated a proportionally heavy carriage.

The progress of improvement has ever been slower in the construction of gun carriages than in the manufacture of ordnance, and the carriages of the 17th century form no exception to the rule. They were rude and unwieldy and fulfil scarcely any of the conditions necessary for a serviceable carriage. They were formed of two large cheeks, or brackets, whose general outline was much the same as the brackets of our own bracket trails, connected together by four transoms, three in front of the shoulder, and

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* . . . . "Thou hast talked
Of Basilisks, of Cannon, Culverin."
First part of Henry IV. Act II. Sc. 3.

one at the end of the trail.* The length of the cheeks was 1½ times the length of the gun, their thickness was 1 calibre, and they were made of "elme or other planke that is not apt to split and cleave."—(Norton).

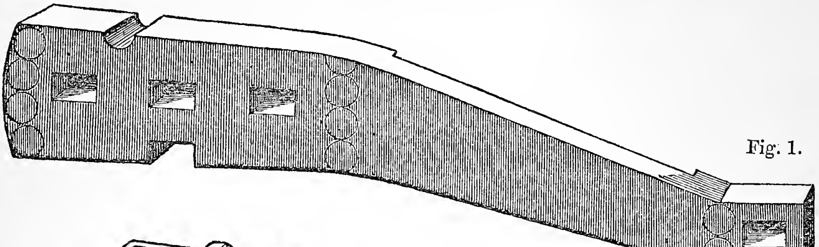

Fig. 1.

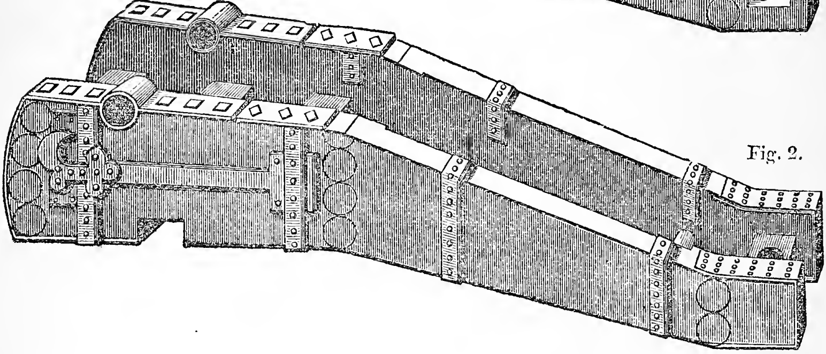

Fig. 2.

The transoms were called, from the point of the trail forwards, the "tayle transum," the "coyne transum," the bed transom, and the fore transom. The fore transom was 3½ calibres long, so that ½ a calibre being mortised into either cheek there remained a distance of 2½ calibres between the cheeks at the breast of the carriage. The "tayle" transom was 5 calibres long, which in like manner gave a space of 4 calibres between the brackets at the end of the trail. The transoms were 1½ calibres broad and one calibre thick, except the tail transom which was 2 calibres broad and pierced with a hole shod with iron "to passe thorow the pin of the avantrine (avant-train) or fore carriage." The axle-tree, a square body with circular arms, was 6 ft. long, to allow a space of 5 ft. between the wheels. Its section at the centre was a square of 1⅔ calibres in side, "and at the place where it pierceth the lymbers or sides of the carriage it must be 1¼ calibres in breadth and 1⅔ calibres in height. . . . . The armes thereof shall be in the thickest place one calibre, and at the end thereof ⅔ of a calibre in thicknesse." The bed in the cheeks for the axletree body was cut immediately below the bed transom, about midway between the shoulder and the breast of the carriage. The axletrees were made of wood until

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* See Figs. 1 and 2. In Fig. 2 the brackets are shown as parallel by some mistake. I am not responsible for either the accuracy or perspective of the sketches, as I have merely copied those given by Norton.

Vallière's time.* The trunnion holes were cut over the central point between the bed and fore transoms, about $\frac{3}{4}$ of the distance between the shoulder and breast of the carriage in front of the shoulder, and iron cap-squares were in use. The gun was elevated by coins resting on the coin transom. The wheels† were half the length of the piece in diameter as a general rule, but $\frac{1}{12}$th to $\frac{1}{6}$th more was allowed for the smaller pieces. The nave of the wheel was 3 calibres in diameter and $3\frac{1}{2}$ calibres long, and there were 12 "spoakes or rayes." The felloes were six in number, and were secured with tires, their section being a square of one calibre in side. The avantrine (limber)‡ was little more than an "axtree (axletree) and a payre of wheeles to draw the Peece into the field," the wheels being generally of less diameter than those of the gun. The ammunition was conveyed on small carts, or in wheelbarrows, or on men's backs. The gunners of course walked on foot beside their gun, much as they do at the present time in the field batteries, and partly from this cause, partly also from the weight of the gun and the unwieldy structure of the carriage, the field artillery can scarcely be said to have possessed in any appreciable degree the most important attribute of that service—mobility.

Fig. 3.

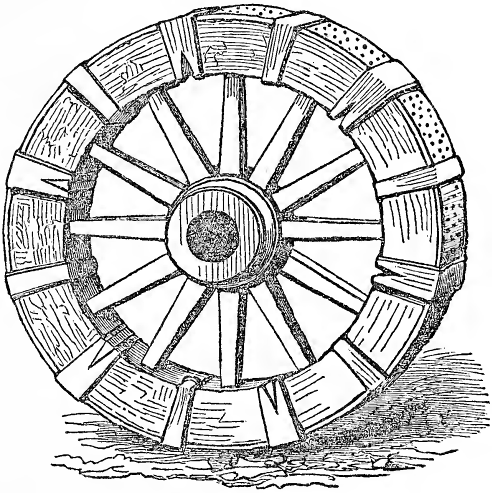
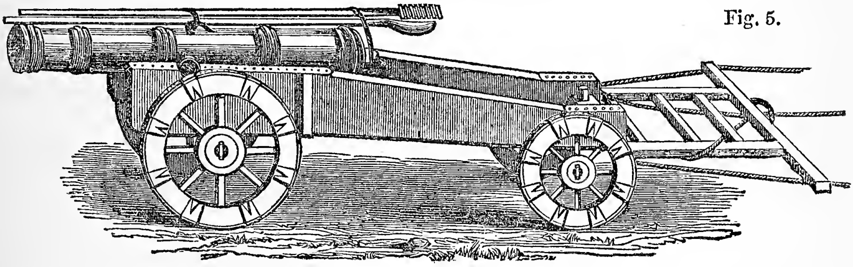


Fig. 4.

Fig. 5.



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* Favé's "Hist. et Tactique des trois Armes," p. 112. See Fig. 3.
† See Fig. 4. ‡ See Fig. 5.

While the unwieldiness of the carriage was to a great extent the result of the extraordinary length and weight of the gun, the size of the gun itself was a necessary consequence of the feebleness of the powder. The proportions used in its manufacture were five pounds of saltpetre, one pound of coals (or charcoal), and one pound of brimstone; and the details of the process, hardly worth quoting here at length, may be found in Norton, p. 144. The testing of the powder was a simple operation. "If it be of a blewish colour, a little inclining to red, it is good; if it do not black much your hand, it is a good signe. Also if it have a sharp biting taste upon the tongue, and if it burn with a sudden flash, it is good."—(Eldred p. 26). I find no mention of proof-charges in works on artillery before Binning's "Light to the Art of Gunnery," 1689; but the following passage from Dryden's "Annus Mirabilis" proves that fire-proof was known at least as early as 1667, the year in which that poem was published:—

> Our careful monarch stands in person by,
> His new-cast cannons firmness to explore;
> The strength of big-corned powder loves to try,
> And ball and cartridge sorts for every bore."

Round shot, as we may learn from Shakespeare, were made of three materials—iron, stone, and, for small pieces occasionally, lead.*

The following table, giving their relative weights, is from Eldred:—

Diameter of shot.	Iron.		Lead.		Stone.	
ins.	lbs.	oz.	lbs.	oz.	lbs.	oz.
4	8	15	11	5	2	13
6	30	10	45	0	11	14
8	72	10	106	8	26	12
10	138	0	207	0	51	10

Besides round shot, many other kinds of projectiles were in use. During the first siege of Bristol, 1643, "Captain Fawcett planted his mortar piece upon a battery and much tore the fort against him with grenades . . . But Captain Clerk, Ancient Hodgkinson, and some others, running upon our men with fire-pikes, neither men nor horses were able to endure it. The fire-pikes did the feat."† Case shot were used at the second siege of the same city in 1645,‡ and mortar shells did execution as well at the unsuccessful attempt on Lathom House in 1644 as at the

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* Henry V. Act. I. Sc. 2. Love's Labour Lost, Act. III. Sc. 1. King John, Act. II. Sc. 1.
† Warburton's "Prince Rupert, &c." Vol. II. p. 163.
‡ Carlyle's "Letters and Speeches of Oliver Cromwell," Vol. I. p. 246.

reduction of Basing House in 1645.* Cromwell in his letters speaks of fire-balls,† and Milton had heard of chain shot—

> "Chained thunderbolts, and hail of iron bolts."
> *Paradise Lost, VI.*

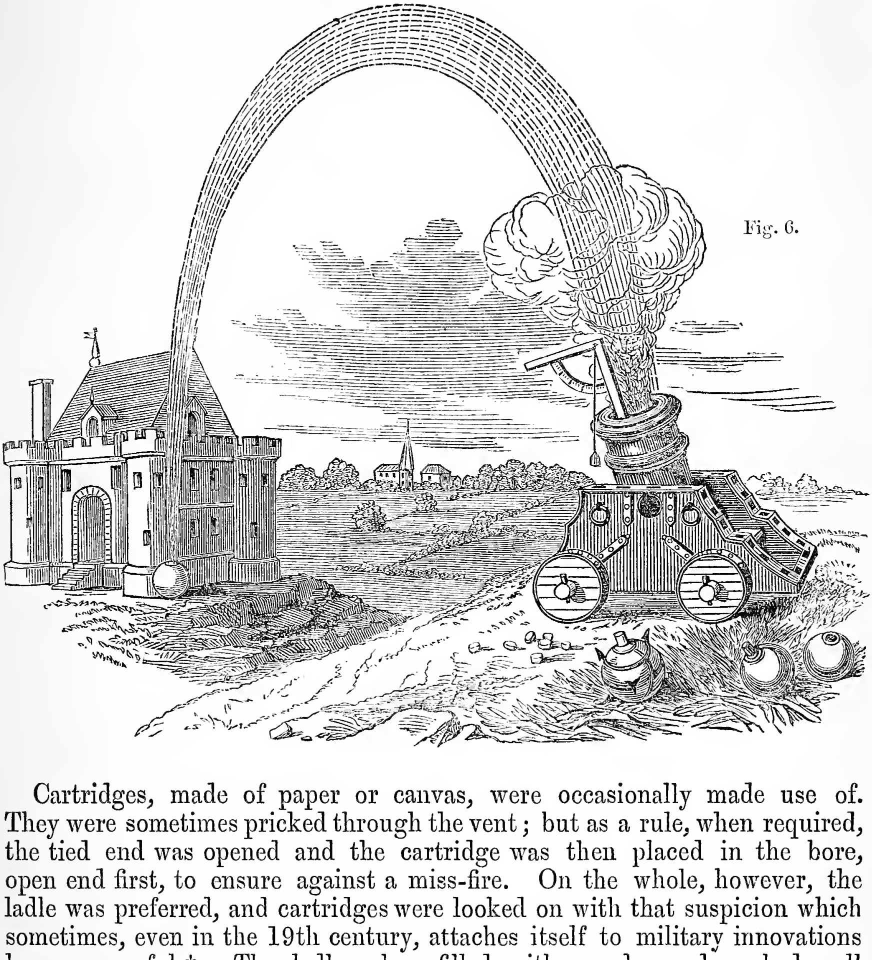

Fig. 6.

Cartridges, made of paper or canvas, were occasionally made use of. They were sometimes pricked through the vent; but as a rule, when required, the tied end was opened and the cartridge was then placed in the bore, open end first, to ensure against a miss-fire. On the whole, however, the ladle was preferred, and cartridges were looked on with that suspicion which sometimes, even in the 19th century, attaches itself to military innovations however useful.‡ The ladle, when filled with powder and pushed well home to the bottom of the bore, was turned upside down, and it required some skill to withdraw it without carrying down with it some of the powder—"a foule fault for a professed gunner to commit. . . Let the gunner," says Eldred, p. 42, "endeavour to set forth himself with as comely a

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* Carlyle's "Letters and Speeches of Oliver Cromwell," Vol. I. p. 253. I have purposely avoided entering into a description of mortars in a paper on Field Artillery. Fig. 6 may supply the deficiency.

† Ibid. Vol. I. p. 257.

‡ Smith's "Art of Gunnery," 1600, p. 81. Norton, p. 128. Eldred, p. 25.

posture and grace as he can possible, for the agility and comely carriage of a man in handling his Ladle, & Spunge, and lading his Peece is such an outward action as doth give great content to the standers by . . . and take heed you shame not yourself in bringing some powder out again with the ladle, which is imputed a great shame to a gunner."

The foregoing passage and some words of command preserved in Eldred prove that the rudiments of drill, however rude and cumbrous, were already in existence. To load a gun 13 words of command were required:—

1. Put back your Peece.
2. Order your Peece to load.
3. Search your Peece.
4. Sponge your Peece.
5. Fill your Ladle.
6. Put in your Powder.
7. Empty your Ladle.
8. Put up your powder.
9. Thrust home your wad.
10. Regard your shot.
11. Put home your shot gently.
12. Thrust home your last wad with three strokes.
13. Gage your Peece.

The rate of firing is given at 8 shots an hour in all the old books I have seen. "One may well make 10 shots an hour, if the peeces be well fortifyed and strong; but if they be but ordinary peeces, then 8 is enough, always provided that after 40 shots you refresh and coole the peece, and let her rest an houre, for fear lest 80 shots shall break the peece, being not able to endure the force and heat."—Eldred, p. 165.

Norton gives the following note on the penetration of round shot: "A cannon at 120 paces" (200 yds. if geometrical paces), "will pierce a wall or rampart meanely settled 15 or 16 foote, and being well settled onely 10 or 12 foote, but in close sandy ground 20 or 24 foote deeper."—p. 136.

The following range tables are from Eldred :—

Gun.	Elevation.										
	P.B.	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.
Whole Culvering	460	630	900	1120	1330	1460	1770	1990	2120	2430	2650
Demy Culvering	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400
Saker	360	560	720	910	1090	1270	1450	1630	1810	1990	2170
Falcon	320	480	640	800	960	1120	1280	1440	1620	1760	1920

I have not given any of Norton's ranges, as they are avowedly taken from a foreign work by Alexander Bianco, and most probably were quite unsuited for British ordnance. Eldred lays great and just stress on the importance of good range tables, and he seems to have taken great pains in making his own. He was for 60 years a gunner, during the reigns of Queen Elizabeth, James I., and Charles I., and as he kept a register (pp. 52 and 57) of all the practice he carried on during the greater part of this long series of years, he no doubt "set forth truer tables than he did ever see." "I made me a book wherein I did write down all my shot that I had occasion to make from time to time, noting the Peeces, the platform, the mark, the distance, the advantage of the peece, and lastly the fall of the shot; whether it were wide, short, or gone . . . and this my observation I have diligently practised almost 40 yeeres."—p. 77.

Notwithstanding his care, however, his ranges for the Demy Culvering cannot be correct. It is difficult to explain how he fell into the error of assigning equal increments of range to equal increments of elevation, for he seems to have been aware of the fallacy of such an hypothesis, when he says, "neither doe I think that the" (ranges corresponding to the) "degrees, from 1 to 10, do increase proportionally; but I leave this to be discussed by some learned mathematician that loves curiosity."

His mistake may have occurred in this way. He made up his tables, not by tabulating the results of any large consecutive number of rounds carried on under the same conditions, but from a record of isolated shots, fired singly perhaps, and at considerable intervals of time, and under very different conditions. A range table thus constructed would always be of doubtful authority, and although Eldred may have carefully calculated his Demy Culvering ranges, an imperfect result could only be expected from such very imperfect data. With all its errors, however, Eldred's range table, constructed from the observation and record of actual practice, is undoubtedly a far nearer approximation to the truth than that of any cotemporary writer; and we must look with suspicion on every early range table, Eldred's only excepted, if we believe the statement made by Smith,—"many authors have taught how to make a table of Randons, whereas some of them never shot in any piece of Ordnance in their lives."*

The accuracy of the guns may to some extent be estimated by the following extracts from Eldred, p. 72:—"I layed one day a Demy Culvering, being 53 score (1060 yds.) to the Δ, at 5 ins. without the dispart, and made a good shot to that mark. Then I desired to try if I could shoot with the same Peece again, with the same powder, wad, and shot, as I did before; and laid it, as precisely as I could for my life, as she lay before to the hole that the first shot made, and that shot fell short of the other by 4 yds.; whereby I might see the great uncertainty of shooting in such a long distance, and therefore let not the best Artist that is ever think to hit a mark alway at such a distance; but if the mark had been nearer . . I hold it possible to shoot within a yard compasse if he take care to dispart his Peece truly, and be careful to lay her well, if the mark, as I said, be 12, 18, or 20 score (240, 360, or 400 yds.)." In another place he speaks of the "marvellous uncertainty of the shooting in great Ordnance at a long distance, the variety† whereof have stumbled many good arts men, and troubled many good wits to find out the variety of shot," and he gives his opinion that firing at long ranges would be "of no great use in service," p. 60. He is also careful to observe that "there is much uncertainty in the flying of a shot, and great difference may happen in loding, wadding, and in laying the Peece by the Quadrant," p. 76. Norton had not reached so high a point in practical gunnery, and he plainly says, p. 107, that

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* "Art of Gunnery," Blackletter. London, 1600, p. 32.

† i.e. variations.

"using like Powder, Shott, and having like temper and accidents, he shall always make thereby the like shot." The following results of practice carried on are from Eldred :—

Guns.	Elevation.	Range.	Under.	Over.	Wide.	Hits.
		yds.	yds.	yds.	yds.	
Basilisk..................	2°	1200	—	—	—	Thro'.*
〃	4¾°	2000	400	—	—	—
Whole Culvering......	5°	1480	—	20	—	—
〃 〃	8°	2280	—	160	—	—
Demy Culvering......	3¾°	1060	—	20	—	—
〃 〃	3½°	1050	—	10	—	—
〃 〃	3½°	1050	—	10	—	—
〃 〃	3¼°	1040	—	—	—	Thro'.
〃 〃	3½°	1110	10	—	—	—
〃 〃	3½°	1120	—	—	—	Thro'.†
Saker...	2½°	904	10	—	—	—
〃	3°	920	—	6	—	—
〃	5°	1270	10	—	—	—
〃	5°	1270	10	—	—	—
〃	5°	1300	—	20	—	—

The "wides" were evidently not measured. The groups of shots bracketed together were fired at Dover from the same platform and the same gun. The "under" and "over" do not refer in all cases to the ranges given in p. 290, but give the first graze of the shot with regard to the target fired at. The discrepancy with regard to range which may be observed between this record of practice and the range table, p. 290, is apparent, not real, as the latter was intended for guns firing on a horizontal plane, and the former gives the results of practice carried on with guns placed on platforms which were all, more or less, elevated above the mark fired at. On the whole the vice of the guns of the 17th century, in regard to accuracy, seems to have been, not so much the absolute inaccuracy of any individual gun, as the great difference of range that existed between any two guns of the same length, weight, and calibre, fired under the same

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* Eldred speaks with great exultation of this shot. "It did just hit the mark, to my great credit and reputation," in the presence of Sir R. Bret, Lieutenant of the Castle of Dover, 15th Aug. 1613.

† Fired from a platform considerably elevated above the target fired at. I have represented Eldred's phrase "a little long," "a little short," by 10 yds., as the case may be.

conditions. Norton had some vague notion of this truth, and he declares that "a gunner ought to have an entire and perfect knowledge of the condition and quality of his Peece, by experience made by former practises in her," p. 110. But that the guns were capable *individually* of making fair practice can scarcely be doubted. "To fayle at the first shot," says the same writer, "if the gunner be not acquainted with the Peece and Mark, is passable; and at the second to fayle is pardonable; but to fayle of a fair shott at the third time is too much, and argues but little judgment and discretion in such a gunner."

A breaching battery was supposed to consist of 18 guns, — 8 cannon, 6 culvering, and 4 demy-culvering. "The cannon playing at right angles (to the wall) are to batter and shake it by reason of the waight of their shot; the culverings play traversely and cut out that which the cannons have battered; and the demy-culverings to play upon the flankers and defences, as also to hinder the sallyes of the besieged, and discover and dismount their Ordnance. The distance that a battery for either should be made ought not to be above 120 paces* (200 yds.), or 150 at the most, or at 80 or 90 (130 to 150 yds.) if possible; the lesse the better, yea though it were at the edge of the Dyke; for the nearer they are, the greater are their forces."—Norton, p. 136. It is extremely doubtful whether these directions, excellent as they are, were ever attended to practically. If we may credit Lord Clarendon, 1000 "great shot" were spent upon the walls of Donnington Castle, "without any other damage to the garrison than the beating down some old parts thereof."† It required some 500 rounds to make a practicable breach in the walls of Basing House, 1645; and "two reasonable good breaches"‡ in the church tower of Tredah, in Ireland, were only made after 200 to 300 rounds had been fired by Cromwell's guns. The breaching batteries in these cases must surely have been established at a long range. Yet on the other hand the batteries which failed to reduce Latham House were established at 200, 100 and 60 yds.§

The proper draught for a horse was generally allowed to be about 500 lbs. — the weight drawn by a Horse Artillery horse at the present time, exclusive of the driver and his kit. An ox was considered to be capable of 600 lbs. draught. Twenty-three horses, "at least," were required for a cannon on good ground; 15 or 17 for the demy-cannon; and 9 for a culvering. These were harnessed "to go double as they do in coaches."||

The knowledge of theoretical gunnery possessed by the very best gunners of the time was singularly erroneous and defective, and their conception of the nature of the trajectory, two right lines, the *motus violentus* and *motus*

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* Geometrical paces.

† "History of the Great Rebellion," p. 541.

‡ Carlyle's "Letters, &c. of Cromwell," Vol. II. p. 60.

§ "Journal of Siege of Lathom House," by Capt. E. Halsall; in Appendix to "Memoirs of Col. Hutchinson," by Mrs Lucy Hutchinson. Bohn's series.

|| Old pictures show a driver mounted on every alternate pair of horses. A 24-pr. gun was taken at Naseby, drawn by 26 horses, and guns drawn by 24 horses are mentioned in Rupert's correspondence.

naturalis, connected by a curve, the *motus mixtus,* is sufficiently explained by Fig. 7. Fig. 8 shows a gyn.

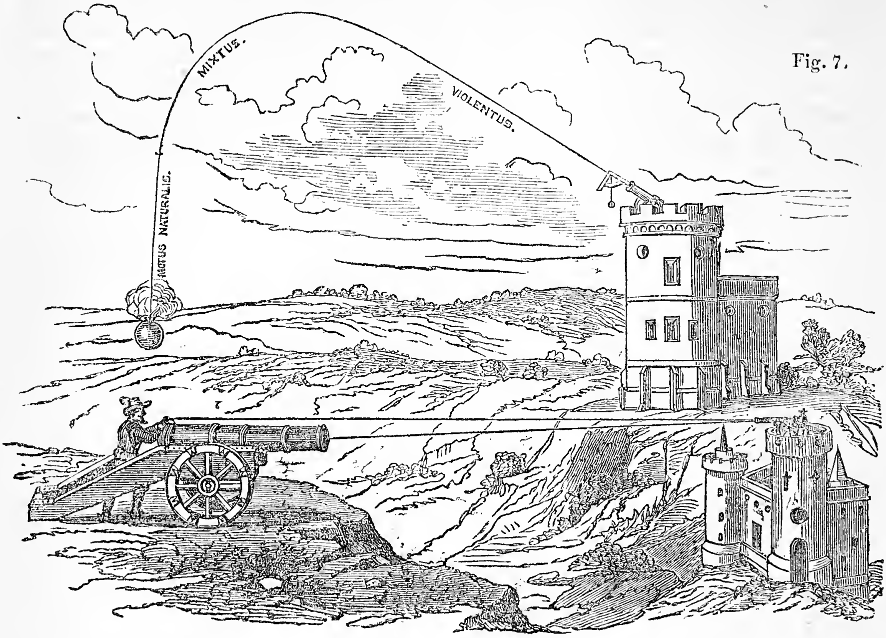

Fig. 7.

Although artillery can scarcely be said to have possessed any organization at all on the outbreak of the Great Rebellion, yet the separation of the service into the two grand natural divisions of garrison and field artillery had made itself felt a full century before. More, in explaining to Wolsey, the reasons why Henry VIII. abandoned the idea of besieging Boulogne in 1523 writes :—"His Highness thinketh that the weteness of the cuntre, upon the rivers side, shall not suffre his army to march with Artillery, either grose enough for batery, or sufficient for the feld."* The existence of this division, the foundation-stone of all organization of the artillery arm, was rather theoretically acquiesced in than practically acknowledged in the 17th century, and a train of artillery was an indiscriminate jumble of various calibres. One gun was allowed for each thousand men of the other arms, and as a consequence 30 guns, 9 cannons, 8 demi-cannons, 6 culverings, and 7 sakers, or other small guns, were required for an army of 24,000 infantry, and 6000 cavalry. For such a train 1524 horses and 588 carters, or wagon-drivers, were necessary. The position of the commander of the artillery differed from that of the same officer in a modern army fully as much as the guns of the two periods. "The Generall of the Artillery hath alwayes a part of the charge, and when the chief General is absent he is to command all the army, and this use I have seen and known to be the practice and use of Count Charles de Mansfelt, of Monsieur La Mot, of

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* State Papers. More to Wolsley, Vol. I. p. 137 Quoted in Sir T. Scott's "History of the British Army."

Count de Bassus, of Count de Baras, of Don Louis de Valasco, and of Count de Bucquoy, Generalls," Eldred, p. 112. The General was provided with 2 Aides-de-Camp, 1 Treasurer, 1 Pay Master, 1 Camp Master, and 1 Muster Master, these to be "not onely honourable men, but men well experienced in the warres." There were further, 15 gentlemen accustomed to Artillery (answering to our Captains), 12 Conductors, 4 Master Gunners (answering to our firemasters), 80 common gunners (whose duties were in many ways equivalent to those of our lieutenants), 30 pack bearers, 2 forgerons "to make fire," 2 marshals, 4 carpenters, 50 miners,* 2 coopers,

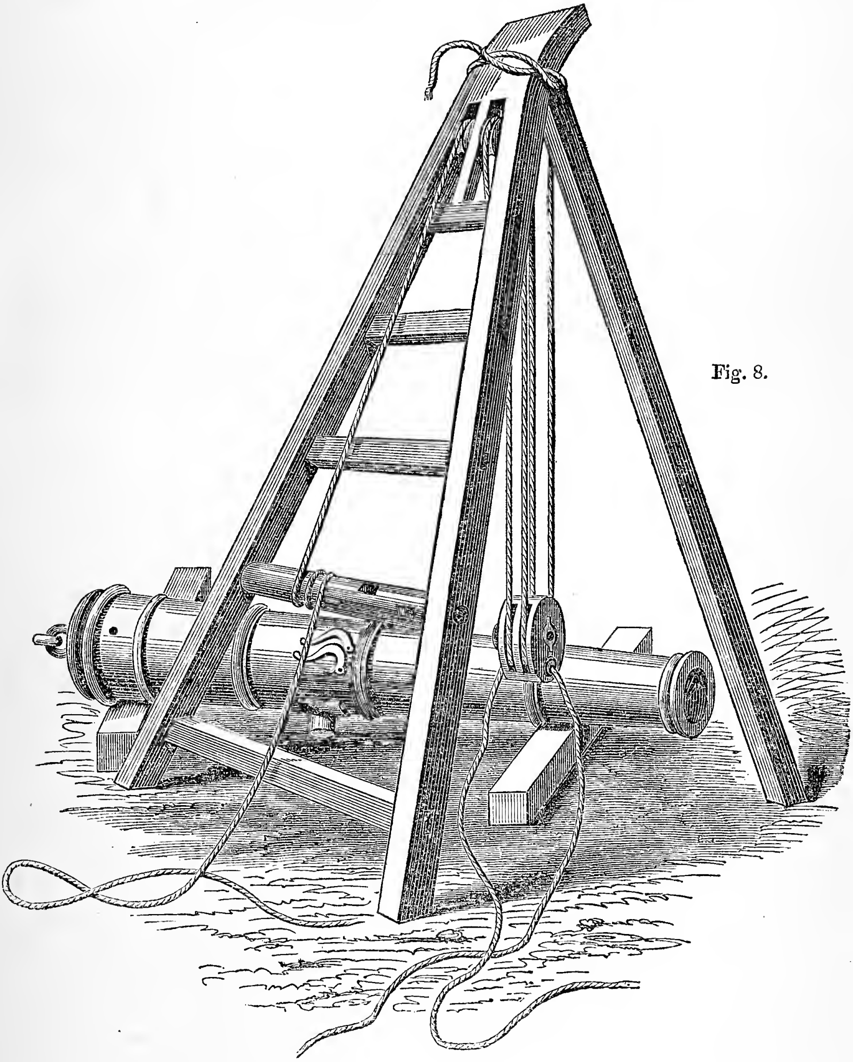

Fig. 8.

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* The first mine ever sprung in England was at the siege of Lichfield, by Prince Rupert in 1643. It was constructed by the colliers of the neighbourhood.

30 carpenters extraordinary, 2 Engineers of fireworks, 6 Petarders, 2 Engineers of Fortification, 1 Provost with Lieutenant and Halbardiers, 100 Mariners, "chiefly such as use the rivers or streames," 1 Master Quartiller, 1 Doctor, 2 Chyrurgions, 2 Barbers, 1 Apothecary, 1 or 2000 Pyoneers, 2 Tenders with master, and 1 Chaplaine.

In spite of the addition of the chaplain, the gunners were profane and dissolute men. If they resembled their brethren of the militia a few years later, as they no doubt did, they were wont to attend a morning drill—

" . . . . a short essay,
Then hasten to get drunk, the business of the day,"*

and the following quaint anecdote from Binning's "Light to the Art of Gunnery," proves that they swore as terribly as the soldiers with whom Captain Shandy served in Flanders. "My first discourse is of gunners, because many times it falleth out that most men employed for Gunners are very negligent of the fear of God. Many examples of this nature might be alleged and produced from the sad experience of preceding times; but I thought fit to intimate only this one, for the terrifying all Godless, and the confirming all Godly Gunners; which example I had from Seyger van Regterne, General of the land of Overyssel, in his Diurnal from Amsterdam to East India. In the 38th Folio of that book he saith, That in the year of our Lord, 1631, in the month of April, there was on the island Nero a Gunner whose name was Cornelius Slime, but a very godless and prophane man, who at no time could speak but he would be cursing and swearing; and when any would ask him what was his hopes after this life were ended, his answer was, It may be to Heaven or it may be to Hell; but, said he, if I do go to Hell, there I will sell Tobacco and Brandy, and that would be good medicine for the Devils. But one day this Cornelius Slime, in the presence of my author and many more, being cursing and swearing and many times giving himself to the Devil; in the mean time, in presence of all those people, the Devil lift him up in the air, and let him fall to the ground with a great noise; but the second time being caught up by the Devil, he was taken where never man living could find him. From the like the Lord deliver us all! But if experience had not taught me what that the lives of many gunners are, I would have said nothing of it here."

The foregoing sketch may give some notion of the nature of the Field Artillery, *matériel* and *personnel,* at the breaking out of the civil war between Charles I. and his Houses of Parliament, but there are almost insuperable difficulties to be overcome in writing any satisfactory account of the tactical use made of the Artillery in the campaigns that followed. The ordinary histories of the time, written by men without "the least tincture of the art of war,"† do not often trouble themselves about military operations, and when they do touch on such subjects they are rarely instructive. In such narratives of battles as are still extant, little attention is paid to the Artillery,

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* Dryden's "Cimon and Iphigenia."

† Rapin's "History of England," Vol. II. Book 21, p. 499.

but we can scarcely feel surprise at the brief and casual notice bestowed on this arm by the writers of the 17th century, when in the famous military history of the 19th century, Napier's "Peninsular War," the services of the Artillery, with the single exception of Norman Ramsay's glorious exploit at Fuentes d'Onore,* are persistently and entirely ignored. Finally, the violent party spirit of the combatants casts a doubt over the credibility of every history of the civil war written at the time, or afterwards, by those who had taken any part in the struggle. For instance, the Royalists declare their fire at one of the sieges to have been accurate and effective, while a Roundhead writer speaks of the same fire in the following terms:—"The enemy have made above 1000 great shots against the town, and yet slain with them but one old man that was making his will just as the bullet hit him (the like at Gloster, where but one old woman and a pig was killed with a cannon) and they consumed at least 200 barrels of powder in shooting in the great and lesser guns."†

Before entering on the Great Rebellion, the Scotch invasion of 1640, the "bellum episcopale," demands a short notice.

The Scots crossed the border under the command of Alexander Leslie, "that old, little, crooked soldier," who had served with distinction as Felt-Marshal under Gustavus Adolphus.‡ Lord Conway, the English leader, was ordered to dispute the passage of the Tyne and the occupation of Newcastle, and he consequently threw up some field works on Stella-haugh. These works were quickly demolished by Leslie's artillery, and under cover of its fire a party of Scotch cavalry advanced across the river. The English horse charged and drove back the enemy, but were in turn themselves checked by the Scotch artillery. The Scots again crossed the river, and the English were finally obliged to retire after suffering some loss from the Scotch battery. This battery was composed of leather guns, introduced probably by Leslie, "an invention of white iron, tinned, and done about with leather, and corded so that they could serve for two or three discharges. They were light and carried on horses, and when they came to Newburn" (the affair just described), "the English army that defended the ford was so surprised with a discharge of artillery, some thought it magic, and all were put in such disorder that the whole army did run with so much precipitation that Sir Thomas Fairfax, who had a command in it, did not stick to own that till he crossed the Tees his legs trembled under him."§ These guns may possibly have been manufactured in Scotland, as it has been asserted that the leather guns of Gustavus Adolphus were devised by Robert Scot, a Scotch officer in his service. Leather guns were afterwards used in England by the Roundheads. "At Cropredy bridge and thereabouts we overtook Waller's army which we engaged and beat, took Weemes, General of their Artillery, prisoner, and

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* Ramsay was not even mentioned in dispatches for Fuentes d'Onore. *Tempora mutantur.*

† "Letters from a Sub. Officer of Lord Essex' army," Archasol, 36, 231. Vicars, "God in the Mount," Par. Chron. 3, 230.

‡ Cust's "Warriors of the Civil Wars," Vol. II. p. 613.

§ Bishop Burnet's "History of my own Times," Book 1.

withal took his leather guns which proved very serviceable to the King."* I find that in 1626, the 2nd of King Charles I., some improvement was attempted in the Ordnance, for one Arnold Rotispen obtained a patent for fourteen years "for making guns of all sorts, both great and small, after a new way or manner, not formerly practised by any within these dominions."† It is possible that this refers to leather guns, for Gustavus first used them in 1625. Under any circumstances they fell into disrepute ere long, and a later writer speaks of "the leather guns by which the King and Country hath been cheated."‡

Early in October, 1642, Charles the First took the field. The Parliamentary General, Essex, chose the Earl of Peterborough as his General of Artillery,§ and possessed a large train, some of his guns being "in a very splendid equipage."§° The King's faithful Master General of Ordnance, Sir John Heydon, commanded the Royalist Artillery, which at first appears to have been inferior to that of the Roundheads, but was later in the year in "very good order."|| Lord Macaulay considers it "a remarkable circumstance that the officers who had studied Tactics in what were considered the best schools under Vere in the Netherlands and "under Gustavus Adolphus in Germany, displayed far less skill than those commanders who had been born to peaceful employments, and who never saw even a skirmish till the civil war broke out."||° I can see but little real foundation for the imputation contained in this imposing sentence. Lord Chancellor Clarendon plainly says that, in the Royalist army at least, "the soldiers were the least part of the army and the least consulted with."¶ The dregs of those who had served abroad attained to commands; but they were appointed, not because they had seen service, but because they had great influence. Lords Holland and Arundel were despicable as soldiers, and were put in authority solely by Court favour; and the Marquis of Hamilton boasted openly that all he had brought home with him from his German campaigns was the truculent High Dutch Maxim—" ein barmherziger Soldat ist ein Hundsfot vor Gott."¶° Further, Lord Macaulay implies that to see service is the one thing needful to make a good soldier, an assertion which all history proves false. There is a kind of stupidity impervious even to experience, there are men who are incapable of learning on the battle field; and *poëta nascitur, non fit* is as applicable to soldiers as to poets.

At the outset of the war the King, starting from Shrewsbury, is said to have turned the flank of the Roundheads by a brilliant stroke of strategy, and to have interposed between Essex and London. The King's object no

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* Gwynne's "Military Memoirs of the Great Civil Wars," p. 42.

† Grose's "Military Antiquities," Vol. I. p. 403.

‡ Binning's "Light to the Art of Gunnery," 1689, p. 104.

§ "List of the Army raised under the command of His Excellency, Robert, Earl of Essex." London, 1642.

§° Clarendon's "History of the Great Rebellion," p. 310.

|| Ibid's 325.

||° Macaulay's "History of England," Vol. I. pp. 112, 117.

¶ "History of the Great Rebellion," p. 206.

¶° Cust's "Warriors of the Civil Wars," Vol. II. p. 438.

doubt was to march upon London, and Essex's object was to prevent him, but it seems to me to have been little more than a happy chance that led the King between the Parliamentarians and the capital. On leaving Worcester to pursue the King and cut him off from London, Essex's train of Artillery "was so very great that he could not move but in slow marches, so that the two armies, though but 20 miles asunder when they first set out and both marched the same way, they gave not the least disquiet in ten days' march to each other: and in truth, as it appeared afterwards, neither army knew where the other was."* Essex, urged on by messages from London, was at length persuaded to leave his ordnance behind him, and caught up the Royalists at Edgehill, early on the morning of the 23rd Oct. 1642. The Royalists occupied a good position which they were unwilling to leave, and the Roundheads were loth to begin an action without their guns. The battle consequently did not begin before 2 p.m., opened by the Roundheads, whose Artillery had arrived, firing three guns, as some narrate;† or according to others by the King in person discharging a piece.‡ The Royalists were drawn up with their infantry in the centre in three lines; the cavalry on either flank of the infantry; and the artillery, protected by a small detachment of infantry, on the outer flanks of the cavalry. The Royalist cavalry charged at once, and with success as regarded their right wing; but in so doing they repeated the error of Tilly at Leipsic, eleven years before,—they isolated and silenced their own guns; and the successful wing delaying to pillage, the Roundhead reserve cavalry charged the right wing guns, inflicting but little injury it is true on the guns and gunners, but doing almost irreparable damage to the harness. Little more than a month afterwards Prince Rupert says,—"we took thirteen handsome field pieces of brass . . . a great strengthening to our train of artillery . . . yet for want of harness we were forced to sink some of our iron guns in the Thames."§ The Royal cavalry seem to have succeeded in silencing the Roundhead artillery, for towards the close of the battle, according to Sir E. Cust, the King opened a "brisk cannonade which the Parliamentarians could not return, for all their cannon had been nailed and their cannoneers were killed or had fled." No further reliable account can be given of the part taken by the artillery at the battle of Edgehill, for the accounts of this encounter are so contradictory and conflicting that it would be a hopeless task to reconcile them.

At the siege of Bristol, 1643, a number of field guns were employed, but, as the Royalists themselves were obliged to allow, with little result. "Our ordnance was of little effect; only, as we heard,|| one of their cannoneers vapouring in his shirt on the top of the fort, was killed there for his foolhardiness."¶ In this year at Braddock

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* Clarendon's "History of the Great Rebellion," p. 327. Guizot's "Charles I. and the English Revolution," Vol. II. p. 9.

† Warburton's "Rupert, &c." Vol. II. p. 20.

‡ Lingard's "History of England," Vol. X. p. 79.

§ MS. letter of Captain Pym, one of Rupert's captains in his corsairage.

|| Like the Romans at Veii, no doubt,—"jam per longinquitatem belli commercio sermonum facto."—Livy. 5, 15.

¶ Rupert's Diary.

Down, Sir Ralph Hopton displayed an unusual example of what may be effected by even a single division of a battery, when properly used. "Having winged his foot with his horse and dragoons, he advanced within musket shot of the enemy who stood without any motion. Then perceiving that their cannon were not yet come up, he caused 2 small minion Drakes (all the artillery he had) to be drawn under cover of small parties of horse, to a convenient distance from the body of the enemy; and after two shots of those Drakes (which not being discerned and doing some execution, struck a terror into them) advanced with his body upon them," routed them and took "4 brass pieces (whereof two were 12-prs.) and one iron saker."*

The breastwork of fascines erected at Lansdown, the same year, was for some unexplained reason placed *behind* the guns that crowned the height occupied by the Roundheads. When the Cavaliers were well nigh defeated by the repeated charges of Haslerig's "Lobsters,"—a cuirassier regiment, and the first red-coated soldiers in England—the Cornishmen, who had all along prayed to "have leave to fetch off those cannon" could no longer be restrained, and under Sir Bevil Grenvil they carried the position and won the battle. The failure of the artillery here was more than redeemed by a brilliant feat of arms performed shortly afterwards by Lord Wilmot, who with 1500 cavalry and two guns routed at Roundway down a Parliamentary force of 2000 horse, 500 dragoons, 3000 infantry and "an excellent train of artillery." The guns were first brought to bear on the cavalry and threw them into some confusion, upon which Lord Wilmot at once charged and routed them; and then seizing their guns, which most probably had according to custom been placed on the outer flanks of the cavalry, he completed the victory by turning the artillery upon their own infantry.†

At the first battle of Newbury, the King's artillery is generally allowed to have been almost useless,‡ while, as Gen. Sir E. Cust tells us, "the Lord General thundered from his ordnance from the top of Bigg's hill, though without much effect, and indeed his loss was much greater than that of the King."§ In another passage General Cust says that "many of the cavaliers of note fell before the rebel artillery, which was advantageously posted and well served;"|| but this I take to be a slip of the pen, for although the Earl of Sunderland was killed by a round shot, the Marquis de Nieuville was killed by the blow of a pike,¶ and the Earl of Caernarvon was cut down by some troopers.

The guns did but little damage at the siege of Lathom House, which took place in the spring of the following year, 1644, if their effect be compared with that of the mortar which gave such annoyance to the garrison that they were obliged at length to make a sortie in force and capture it. It was loaded either with stone shot, 13″ in diam. and 80 lbs.

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[*] Clarendon's "History, &c." p. 366.

[†] Ibid. p. 433.

[‡] Warburton's "Rupert, &c." Vol. II. p. 293.

[§] Cust's "Warriors of the Civil Wars," Vol. I. p. 236.

[||] Ibid. p. 292.

[¶] He was merely a spectator, riding with the King.

weight, or with "a grenado," which was about the same diameter as the stone shot and 2″ thick.* On the 16th April "they cast a grenado which fell into the old court, striking about half a yard into the earth; yet it rose with such violence again in bursting, that though its strength was much deadened and lessened by the earth, yet it shook down the glass, clay, and weaker buildings near it, leaving only the carcass of the walls standing about it."†

The leather guns which the Scots, according to Bishop Burnet, carried on horses, were differently moved by the English, and at Copredy Bridge, the same year, the cavaliers took "two baricadoes of wood, which were drawn upon wheels, and in each seven small brass and leather cannon, charged with case."‡ At this battle was taken prisoner, serving in the Parliamentary army, Weemes, the Master Gunner of England. His salary was £300 a year, equivalent to about £1000 a year at the present time; and his duty was "to show the best of his Skill to all that are employed in Gunnery in their Majesties service . . . and at each ones admission to administer an Oath which binds him not to serve any foreign prince or state without leave, and not to teach any Man the Art of Gunnery but what has taken the said Oath."§ Eldred says that the pay of a gunner in his time varied from 6d. to 8d. a day, or about 1s. 9d. in our money.

The Royalists had some 25 guns at Marston Moor. The pieces posted on their right flank were carefully ensconced behind a bank, but by some oversight their outer flank was entirely unprotected. Cromwell at once perceived the weak point, swept round the bank, avoiding the fire, and having captured the guns turned them against their own infantry. This completed the defeat of the Cavalier right. The accounts of this battle that are extant are of such a nature as to preclude any trustworthy account of the battle in general, or of what befel the guns of the Royalist left wing.

The crushing defeat at Naseby, 1645, which virtually ended the war, was undoubtedly in a great measure owing to the ungovernable rashness and precipitation of Prince Rupert; and he failed to display here, as he invariably failed to display, any of the qualities of a great cavalry leader except personal courage. He might have commanded a squadron with distinction, but he was utterly incapable of leading a brigade. At Naseby he forced the Cavaliers prematurely into action, "before the cannon was turned or the ground made choice of upon which they were to fight; so that courage was only to be relied on where all conduct failed so much."‖ He charged with his wonted headlong courage, and as usual he succeeded in worsting the cavalry opposed to him at the first onset; but as usual he was either unwilling or unable to rally his troopers after the charge and complete the rout of the enemy's cavalry, or rejoin the main body of the Cavaliers, where his presence would have averted an irreparable catastrophe, though it might not have sufficed to prevent a defeat. But while Cromwell

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* Halsall's "Journal of the Siege of Lathom House," 15th April.

† Ibid.

‡ Clarendon, p. 522.

§ Chamberlayne's "State of England," Pt. 2, p. 197 of Vol. for year 1691.

‖ Clarendon, p. 590.

was carrying fire and the sword into the heart of the Royalist position, His Highness was engaged in attacking the Roundhead artillery, according to his own account, or, as the Parliamentarians translate it, in plundering. The King had only "12 small guns, none of which appear to have been brought into position,"* for the Prince had hurried on the action so unexpectedly that the guns were not yet "turned," and unlimbering was then a serious operation. The Roundhead guns were not served with much skill, for when the Royalist centre advanced "the whole of the enemy's artillery opened on them, but with little effect."† Indeed it is difficult to avoid concluding that "by the rapid evolutions of the light cavalry, the artillery was reduced to comparative insignificance, and can claim but small share in the honours of the day."‡

Such was the nature and such was the use of the field artillery of the Great Rebellion. Its impotence was due to two causes,—the want of mobility and the want of officers; for the guns, as guns, were by no means incapable of inflicting loss upon an enemy, and the force they represented was considerable in magnitude. But from want of mobility, which arose partly from the gunners marching afoot and partly from the weight of the guns and carriages, this force was incapable of readily assuming the direction in which its effect would be greatest. And from want of any Artillery Officer worthy of the name there was no experienced leader to point out the line along which the force ought to act. Thus a mighty power lay paralyzed and dormant; the bow of a giant was in the hands of a child who had neither strength to bend the bow, nor skill to aim the shaft.

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* "Special Relation, &c." King's Coll. 212.

† Ibid.

‡ Captain Brabazon, R.A. "Soldiers and their Science," p. 146.

HEATON'S STEEL CONVERTING PROCESS.

COMMUNICATED BY CAPTAIN KEATE, R.A.

A concise account of a new method of steel manufacture, "Heaton's Steel Converting Process," which has very recently come into operation, may perhaps be considered of interest to the readers of these papers.

In order to estimate the invention at its full value, the hitherto existing processes, with their scope, should for a moment be considered.

The oldest of these, that by cementation and puddling, involves a series of tedious and laborious operations; the crude iron having first to be deprived almost wholly of its carbon, and then, by the costly method of cementation, made to absorb a sufficient quantity of that substance in a solid state. It is capable, moreover, of dealing with certain of the purest brands of iron only, obtained from a contracted area. With variations and modifications in detail, this was the only method of steel making till Mr Bessemer took the iron world by storm in 1855, with the introduction of his "Pneumatic Process," which, as is well known, consists in the forcing of air by steam power through the molten cast-iron, so that it is thereby converted into oxide of iron, which re-acts on the silicon and carbon, converting the latter with carbonic oxide, which burns out at the mouth of the furnace, and the former into siluric acid, which comes to the top with the slag, and the metal is thus rendered malleable and ready for the tilt hammer at a single heat. The process of blowing a charge of five tons with a 250 horse power engine, takes about a quarter of an hour, after which, as it is found that the metal has become too much decarbonized, the converter has to be "turned down" to receive a dose of spiegeleisen to restore the balance. The conversion into steel is then completed, but in pouring it from the converter into the crane ladle, which is the next operation, a great amount of slag often accompanies it. This is stated to be due to the wearing down of the lining and the *tuyères* at the bottom of the converter, which have to be renewed at least every two days. The steel is next run from the ladle through a perforated plug of fire clay, into moulds of cast-iron of suitable sizes for forgings of different kinds.

It is unnecessary to detail the subsequent mechanical processes of re-heating, rolling, hammering, and the like, which are common to all steel manufactures, but it is important to note the admixture of spiegeleisen, without which the conversion cannot be satisfactorily effected, the destructive action of the process on the converters, and the wear and tear of the *tuyères.*[*] Moreover, the Bessemer process can act with effect on irons of the first brand only.

Coming now to the subject of this paper, Mr Heaton, by his process, professes to manufacture steel of the best quality from any sort of iron, even the most sulphur and phosphorus charged brands, at one operation direct from the pig, a few minutes sufficing to produce the results which are said to be remarkable for their uniformity. The process being chemical and rapid, in place of mechanical and tedious, and the material dealt with of the cheapest, the elements for a minimum of cost are alleged to be presented.

Before describing the *modus operandi*, it will be well to explain that, Heaton's, like Bessemer's system is a direct chemical re-action, and consists in the application to the molten metal of nitrate of soda, which developes the nascent oxygen (a far more powerful agent than heated air), on contact, with an energy tempered to the requirements of the manufacture by means of the apparatus invented for its management, which constitutes the essence of the patent.

The process of conversion[†] is as follows:—

The Heaton Converter is nearly a cylindrical cupola, lined with a 4½-inch fire-brick, the shell of boiler plate, and is surmounted by a plate iron conical cap, and narrower cylindrical flue a few feet in height. The cupola may be supposed, cut in two, horizontally at about one diameter and a half in height, and the bottom part rendered movable and capable of being withdrawn on wheels without disturbance to the supports, &c. of the remaining upper portions of the converter. Means of temporary attachment by clamps and cotters, are provided to connect the two parts; at one side of the cylindrical fixed part of the converter a hopper, with a loosely hinged iron plate cover, is provided, which communicates with the cavity within.

The lower part, or converting pot, has a cylindrical cavity with a flat bottom, the sides near the top edge sloping inwards to a cone all round.

The cavity up to the level of the lower edge of the cone is prepared to hold just the bulk of crude nitrate of soda, required for the volume of liquid iron to be operated upon and the latter when converted. The proportion of nitrate at present employed, being 2 cwt. to the ton of molten iron, a proportion which it is believed may be materially reduced, when the conditions for the most favourable re-action shall be more completely understood.

The converting pot is lined with fire-brick and refractory clay. When the crude nitrate is filled in up to the narrow part of the conical lining, a cast-iron perforated plate is laid upon its level surface, and worked round till its edges bed firmly into and upon the clay lining. In this state the converting pot is rolled in under the upper part of the converter and clamped to it, ready for work.

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[*] From an anonymous pamphlet.—Judd and Glass, Doctors' Commons.

[†] Extracted chiefly from "Practical Mechanic's Journal."—Jan. 12, 1868.

The charge of crude iron is melted with coke in an ordinary cupola, and the contents are tapped out into a crane ladle. This is swung round by the crane and the contents emptied into the open hopper of the converter. The molten iron falls on the cast-iron plate, and re-action is soon evidenced by the appearance of white and grey vapours out of the converter funnel. The plate is melted up with the charge; a burst of brilliant yellow flame indicates when the re-action is at its height. This lasts for from three to five minutes, with 15 cwt. charges, and then rapidly subsides.

The conversion is now complete. The converting pot is detached and rolled away, and the converter is ready for another bottom and another charge.

In the converter is the converted metal called crude steel, covered with a slag at 1·1½ inch thick, consisting of the soda of the nitrate, combined with silica and clayey matter, a small quantity of metallic iron and silicate of iron. The liquid mass beneath is not sufficiently fluid to be tapped, so the converting pot is upset on the iron floor, and is broken into lumps of a convenient size to be brought, after a little renewal of heat, under the shingling hammers and patted into cakes of "crude steel."

This is metal of the purest and finest quality, from which, by two different methods of treatment, either very strong, but soft, tough, and malleable wrought-iron may be made, or fine cast steel.

The above is the whole process of conversion.

The following are certified as the average rupturing strains and extensions at rupture of the steel iron and cast steel, resulting from a series of experiments:—

	Rupturing strain in tons per square inch.	Extension at rupture in per cent of original length.
Heaton's steel iron …………	22·72	21·05
〃 cast steel …………	41·73	7·20

These specimens have been manufactured from "makes" of crude iron, obtained from various and distant iron districts in Great Britain.

A TABLE OF THE NAMES OF THE GREAT ORDNANCE NOW USED.*

COMMUNICATED BY COLONEL CLERK, R.A. F.R.S.

	Height of diameter of each piece, in inches and parts.	Height of the bullet in inches and parts.	Weight of the shot in lbs. and parts.	Compass of the shot in inches and parts.	Weight of corne powder to charge each piece in lbs. and parts.	Weight of the piece in lbs. about.	Length of the piece in feet about.	Thickness of the metal at ye touchhole in inches and parts.	Thickness of metal at the trunnions.	Thickness of metal at the neck of each piece.	Length of the ladle.	Breadth of do.	Length of the planks of the carriage.	Breadth, or depth of each plank at the fore ends.	Breadth of the planks at the lower end.	Thickness of the planks.	Number of men to draw each piece.	Number of horses to draw each piece.	Number of yokes of oxen to draw do.	Distance of paces the piece carries at point blank.	Do. which the piece shoots at utmost random.	Length of coyler rope to draw each piece.
Cannon	8	$7\frac{1}{4}$	64	$25\frac{1}{7}$	32	8000	12	8	$6\frac{3}{4}$	4	$23\frac{1}{2}$	15	$16\frac{3}{4}$	32	20	8	90	16	17	300	1500	70
Cannon Serpentine	$7\frac{1}{2}$	$7\frac{1}{4}$	52	$23\frac{4}{7}$	26	7000	$11\frac{1}{2}$	$7\frac{1}{2}$	$5\frac{2}{5}$	$3\frac{3}{4}$	22	$14\frac{1}{2}$	$16\frac{1}{4}$	20	$18\frac{1}{4}$	$7\frac{1}{2}$	80	14	15	340	1600	66
French Cannon	$7\frac{1}{4}$	7	$46\frac{3}{4}$	$22\frac{11}{14}$	$23\frac{1}{4}$	6500	12	$7\frac{1}{4}$	$5\frac{2}{5}$	$3\frac{5}{8}$	21	$13\frac{2}{5}$	$16\frac{3}{4}$	29	18	$7\frac{1}{4}$	70	12	14	360	1740	64
Demi-Cannon eldest	$6\frac{3}{4}$	$6\frac{1}{2}$	$36\frac{5}{8}$	$21\frac{3}{14}$	20	6000	$11\frac{1}{4}$	$6\frac{3}{4}$	$5\frac{1}{4}$	$3\frac{3}{3}$	22	12	$15\frac{1}{2}$	27	$16\frac{3}{4}$	$6\frac{3}{4}$	65	11	12	370	1800	60
Demi-Can. ordinary	$6\frac{1}{2}$	$6\frac{1}{4}$	32	$20\frac{3}{7}$	18	5600	$10\frac{1}{2}$	$6\frac{1}{2}$	5	$3\frac{1}{8}$	20	$11\frac{1}{2}$	$15\frac{1}{4}$	26	$16\frac{1}{4}$	$6\frac{1}{2}$	60	10	11	350	1700	54
Demi-Cannon	6	$5\frac{3}{4}$	$24\frac{1}{2}$	$18\frac{6}{7}$	16	5000	11	6	$4\frac{3}{4}$	$3\frac{1}{10}$	21	11	16	24	15	6	56	9	10	340	1600	46
Culvering	$5\frac{1}{2}$	$5\frac{1}{4}$	19	$17\frac{2}{7}$	15	4600	$13\frac{1}{4}$	$5\frac{1}{2}$	$4\frac{1}{2}$	3	22	$9\frac{1}{2}$	$18\frac{1}{4}$	22	$13\frac{3}{4}$	$5\frac{1}{2}$	50	8	9	420	2100	40
Ordinary Culvering	$5\frac{1}{4}$	5	$16\frac{1}{4}$	$16\frac{1}{2}$	$12\frac{1}{2}$	4300	12	$5\frac{1}{4}$	$4\frac{1}{4}$	$2\frac{3}{4}$	21	9	$17\frac{3}{4}$	21	$13\frac{1}{2}$	$5\frac{1}{4}$	46	8	9	400	2000	36
Demy Culvering	$4\frac{1}{2}$	$4\frac{1}{4}$	$11\frac{3}{4}$	$14\frac{1}{7}$	9	3000	11	$4\frac{1}{2}$	4	$2\frac{5}{8}$	20	$8\frac{1}{2}$	$16\frac{1}{8}$	18	$11\frac{1}{4}$	$4\frac{1}{2}$	36	7	8	380	1800	34
〃 something less	$4\frac{1}{4}$	4	9	$13\frac{5}{14}$	$7\frac{2}{3}$	2300	10	$4\frac{1}{4}$	$3\frac{3}{4}$	$2\frac{2}{3}$	$19\frac{1}{2}$	$7\frac{3}{4}$	$14\frac{3}{8}$	17	$10\frac{3}{4}$	$4\frac{1}{4}$	28	6	7	320	1600	30
Saker ordinary	$3\frac{3}{4}$	$3\frac{1}{2}$	6	$11\frac{11}{14}$	5	1900	$9\frac{1}{2}$	$3\frac{3}{4}$	$3\frac{1}{4}$	$2\frac{1}{2}$	16	$6\frac{3}{4}$	14	15	$9\frac{3}{8}$	$3\frac{3}{4}$	24	5	6	300	1500	28
Sakeret or Minion	$3\frac{1}{4}$	3	$4\frac{3}{4}$	$10\frac{3}{14}$	$3\frac{1}{2}$	1100	8	$3\frac{1}{4}$	$2\frac{3}{4}$	$2\frac{1}{4}$	14	5	$11\frac{1}{2}$	13	$8\frac{1}{8}$	$3\frac{1}{4}$	20	4	4	280	1400	24
Falcon	$2\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{1}{3}$	$8\frac{9}{14}$	$2\frac{1}{4}$	750	7	$2\frac{3}{4}$	$2\frac{1}{3}$	2	12	$4\frac{1}{2}$	$10\frac{1}{4}$	11	7	$2\frac{3}{4}$	16	3	3	260	1200	20
Falconet	$2\frac{1}{4}$	2	$1\frac{1}{8}$	$7\frac{1}{14}$	$1\frac{1}{2}$	400	6	$2\frac{1}{4}$	2	$1\frac{3}{4}$	10	$3\frac{3}{4}$	$8\frac{2}{3}$	9	$6\frac{1}{2}$	$2\frac{1}{4}$	10	2	2	220	1000	20

A bullet of iron to the like bullet of marble stone is in proportion as 15 to 34.
—— of lead —————————— 4 to 1, and to one of iron as 28 to 19.
Corned powder is to serpentine powder in the proportion of 2 to 3.
Prove your guns with a weight of powder equal to the iron bullet thereof: then with $\frac{5}{4}$: then with $\frac{3}{2}$.

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* Extracted from "The Complete Souldier." Auctore Thomas Smith, 1628.

ANNUAL REPORT

AND

ABSTRACT OF PROCEEDINGS OF A GENERAL MEETING OF THE ROYAL ARTILLERY INSTITUTION, HELD ON MAY 19, 1869.

Colonel A. Benn, in the Chair.

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1. The Committee of the Royal Artillery Institution have the honor to present to the Annual General Meeting their Report and Abstract of Accounts for the year ending 31st March, 1869.

It will be seen by the accompanying Table, that during the past year 75 Officers (including H.R.H. Prince Arthur) have joined the Institution, and, after allowing for casualties caused by deaths and withdrawals, there is a net increase of 41 members.

RANK.	£	s.	d.	April, 1868.	Additions due to promotion.	New members.	Promoted, withdrawn, and deceased.	April, 1869.
EFFECTIVE LIST.								
General and Regimental Field Officers, paying annually	1	5	0	188	+16	+ 5	−16	193
Captains	0	16	0	450	+30	+ 9	−33	456
Lieutenants	0	10	0	517	0	+50	−40	527
Paymasters	0	16	0	9	0	0	0	9
Quarter-Masters	0	10	0	8	0	+ 5	− 1	12
Riding-Masters	0	10	0	5	0	0	0	5
Surgeons-Major	1	5	0	6	0	0	0	6
Surgeons	0	16	0	2	0	0	0	2
Assistant-Surgeons	0	16	0	20	0	+ 1	− 1	20
Veterinary Surgeons	0	10	0	3	0	+ 1	0	4
RETIRED LIST.								
General and Regimental Field Officers	1	5	0	38	+ 8	0	0	46
do. do.	0	16	0	1	0	0	0	1
do. do.	0	10	0	7	+ 1	0	− 1	7
do. do.	0	7	6	4	0	0	− 1	3
Captains	1	5	0	1	0	0	0	1
do.	0	16	0	18	+ 3	0	− 1	20
do.	0	10	0	7	+ 2	0	0	9
do.	0	5	0	6	0	0	0	6
Lieutenants	0	10	0	4	+ 1	0	0	5
Surgeons-Major	1	5	0	2	0	0	− 1	1
Chaplains	1	5	0	1	0	0	0	1
				1297	+61	+71	−95	1334
Honorary Members	0	10	6	39	0	+ 6	− 2	43

2. The General Abstract shews the income and expenditure for the past year. The Balance C^r. is less than at this time last year by £34. 3s. 11d. but this diminunition is more apparent than real; and is caused by expenses connected with the publication of Kane's List, which will be more than compensated by its sale when completed.

The Committee regret the loss to the Regiment and the service of Field Marshal Sir Hew Ross, G.C.B., R.H.A., one of the Trustees of the Institution; and are of opinion that his vacancy need not at present be filled up, there being still two Trustees, while the appointment of a third would cause needless expense in transfer of stock.

3. *Printing and Publication.*—Six numbers of Volume VI. of the "Proceedings" have been issued (Nos. 4 and 5 being double numbers), and the Papers enumerated in annexed list have been published during the past year, very many of them being of great interest; and the Committee beg to express their thanks to those gentlemen who have contributed to the "Proceedings."

List of "Proceedings" printed during the year.

Moncrieff's protected Barbette System. By Capt. A. Moncrieff, Edinburgh Militia Artillery.

Hints for the application of Shrapnel Shell. By Major-General W. B. Gardner, R.A.

Annual Report and Abstract of Proceedings of a General Meeting of the Royal Artillery Institution, held on Friday, 15th May, 1868, Colonel J. M. Adye, C.B., in the Chair.

Experimental Casemates at Shoeburyness. Published by authority of the Secretary of State for War.

A brief Historical Sketch of our Rifled Ordnance, from 1858 to 1868. By Capt. F. S. Stoney, R.A., Captain Instructor, Royal Gun Factories.

Experiments on Friction. By Colonel H. Clerk, R.A., F.R.S.

On the Curved Rack in Moncrieff's Protected Barbette Gun Carriage. Communicated by James White, M.A.

The Abyssinian Expedition. By Lieut. E. F. Chapman, R.H.A.

Notes on Elephant Carriage employed in Abyssinia. Communicated by Lieut. Chapman, R.H.A.

An account of the great Cannon of Muhammad II., recently presented to Her Majesty, by the Sultan, with notices of other great Oriental cannon. By Brigadier-General J. H. Lefroy, R.A., F.R.S.

Intrenchment of Field Artillery. By Lieut. R. Walkey, R.A.

Historical Notes on the Royal Arsenal at Woolwich. By Lieut. G. E. Grover, R.E., F.S.A.

Some account of a Prussian Divisional Manœuvre in the Rhine Province, September 1868. By Major W. H. Goodenough, R.A.

Short Notes on Professional Subjects, 1868.

Norton's American tube well.

Practice carried on at Shoeburyness, February 20, 1868, from a 9-in. M.L. rifled 12-ton gun, mounted on a wrought-iron carriage, casemate slide (1867) at a moving target, to ascertain how many rounds could be fired at a vessel moving at right angles across the line of fire, at a range of 1000 yards.

General Abstract of the Income and Expenditure of the Royal Artillery Institution, from 1st *April* 1868, *to* 31st *March* 1869.

	Expenditure.	£	s.	d.
Printing and Publication	Wages	257	13	10
	Paper,£249.0s.7d.Type&Materials,£253.16s.5d.	507	14	5
	Wood Cuts, £72. 9s., Lithography, £147. 8s.	219	17	0
Chemistry		24	1	4
Photography	Chemicals and Apparatus	31	0	4
	Printing, Mounting, &c.	220	6	1
Drawing		75	4	7
Lectures		13	16	7
Taxidermy		8	19	0
Classes		19	4	0
Library, Books, &c.		174	0	5
Museum		32	18	0
Instruments		32	19	6
Carpenter's Wages, £18. 4s., Materials, £66. 9s. 10d.		84	13	10
Insurance on £5000, to 24th June, 1869		16	5	0
Furniture and Repairs		18	5	6
Sub^s to Societies,£4.4s., Annual do. charged in error,£3.3s.6d.		7	7	6
Stationery		367	14	5
Postage and Parcels		58	11	9
Wages, Clerks and Orderlies		133	5	1
Incidental		57	7	9
War Office Photographs and Lithographs		141	8	6
Cash in hand, 31st March, 1869,	Secretary £8 1 11 Messrs Cox & Co. 1 4 4	9	6	3
		£ 2507	3	3

	Income.	£	s.	d.
Cash in hand, 1st April, 1868		61	3	5
Dividend on £1200 Consols (to 5th Jan. 1869)		35	2	0
Subscriptions, to 31st March, 1869	Annual	1006	17	6
	Entrance	70	0	0
	Paid in Advance	3	5	6
General Printing		534	6	9
Chemistry		10	0	6
Photography	Chemicals and Apparatus	...	...	...
	Printing, Mounting, &c.	275	0	0
Drawing		40	0	10
Taxidermy		9	1	0
Classes		11	2	6
Library, Books, &c.		96	15	1
Carpenter, Wood, &c.		13	2	4
Stationery		214	0	1
Postage and Parcels		34	14	2
War Office Photographs and Lithographs		92	11	7
		£ 2507	3	3

DEBTOR AND CREDITOR ACCOUNT, 31st MARCH, 1869.

	£	s.	d
Printing Materials	80	8	8
Due to W.O. for Photographs and Lithographs	19	3	6
Balance Creditor	1898	12	5
	£ 1998	4	7

		£	s.	d.
Balance Creditor	Consols Stock	1200	0	0
	Cash in hand, 31st March, 1869	9	6	3
Approximate value of	Books and Stationery, for Sale	134	3	6
	Printing Paper, on Stock, and Printed Matter	96	0	0
	"Handbooks" in Stock	180	0	0
	Chemicals (Laboratory) £20, (Photographical) £20	40	0	0
Amount owing by Officers and others.	Books, &c.	44	0	2
	"Handbooks"	86	15	0
	Drawing	0	12	0
	Photography	47	14	11
	Postage	10	13	0
	Printing	15	14	7
	Stationery	78	4	3
	Wood, &c.	4	15	5
	W.O. Photographs and Lithographs	9	7	0
	Classes	3	15	0
	Taxidermy	1	19	6
Amount owing for back Subscriptions		35	4	0
		£ 1998	4	7

Examined and found correct,

G. ROTTON, Lt.-Col. R.A. and Colonel, President of Sub-Committee.

A. D. BURNABY, Capt. R.A., Secretary & Treasurer.

WOOLWICH, 12th April, 1869.

Practice carried on at Shoeburyness, from a 12-in. 23-ton M.L. rifled gun, mounted on wrought-iron carriage and platform, placed on a turn-table, firing through a port representing a portion of an iron fort.

Purchase of mules for the Abyssinian Expedition. (Thanks of Secretary of State for War to Captain F. T. Whinyates, R.A.)

Specimen of slate-coloured Partridge, (presented to British Museum by Lieut.-Colonel L'Estrange, R.A.)

Resistance of the air to spherical projectiles.

Simple formula for determining remaining velocities of all projectiles.

Formula for the calculation of ranges.

On the defects of side-arms for muzzle-loading guns.

Practice carried on at Shoeburyness, May 15, 1868, from a 9-in. M.L. rifled 12-ton gun mounted on a wrought-iron carriage and platform, and firing through a port; and from a 12-in. M.L. rifled 23-ton gun mounted on a wrought-iron carriage and platform, on a turn-table, and firing through a port at a moving target.

Experiments at Shoeburyness to test the power of resistance to Palliser shot, of unbacked iron plates, 10-inches in thickness, in comparison with that of two 5-inch plates bolted together.

Extracts from Official Memorandum regarding the fitting out of the transport ships taken up for the conveyance of troops to Abyssinia.

Trial of Lieut.-Col. Shaw's muzzle-pivoting carriage on board H.M.S. "Prince Albert."

Some observations on the Mobility of Field Artillery.

Experiments made with Professor Bashforth's Chronograph at Shoeburyness during the present year, showing the connexion between initial velocity and weight of charge for the 9-in. M.L. rifled gun with the service shot, and the velocities of the service shot for the 9-in., 8-in., and 7-in., M.L. rifled guns at intervals of 100 feet, supposing the shot to move in a straight line.

Nose bag, in use in Prussia. Communicated by Lieut.-Colonel R. Curtis, R.A.

Penetration of earthen parapet by heavy rifled guns at 70 yards range.

Memo. upon the woods of British Kaffraria. By Lieut.-Colonel Chermside, R.A.

Specimens of different woods from the Bombay Presidency, from a Pamphlet by Dr Gibson, Curator of Forests, Bombay. Communicated by Lieut. Bertie Hobart, R.H.A.

Relative powers, by computation, of the service 9-in. and 10-in. M.L. rifled guns.

Experiments carried on at Woolwich, as to the question of issuing shells filled and plugged, or empty, with fuzes screwed in, for Land Service.

Some Notes on Field Artillery. Campaigns 1859 and 1860, by an Officer, R.A.

The Committee beg to observe that the publication of the second part of Major-General W. B. Gardner's paper, could not have been undertaken at the Institution, on account of the expense of the wood cuts, had the Secretary of State for War not consented to purchase 1000 copies, and the thanks of the Committee are due to Major-General Warde, C.B., Vice-President, for the interest he manifested in furtherance of this object.

Whilst thanking the contributors to the "Short Notes on Professional Subjects," which accompany each issue of the "Proceedings," the Committee hope for a continued co-operation of members in support of this means of imparting information on subjects of professional interest.

The attention of members is called to the "Alphabetical List of the Officers of the Regiment serving on full pay," which also includes Retired Officers on full and half-pay, shewing their army rank. This List, although most useful for reference, does not appear to be generally known. It is published quarterly and issued to subscribers at one shilling a year, or single numbers at sixpence each.

The Committee have great pleasure in informing the meeting that sixty Officers have entered their names as subscribers to the new edition of Kane's List since the last meeting (making a total of 260), and they confidently expect an extensive sale of this work as soon as it is published. The progress of the List has been much retarded owing to Lieut.-Col. Miller having been obliged to return to his regimental duty in India; but already the services of 1915 Officers, and short Biographies of some of the more distinguished, have been carefully compiled and printed. The Committee nevertheless trust that before the close of the present year, subscribers will be in possession of Part I., being the List of Officers of the old Royal Artillery.

Whilst regretting that Lt.-Col. Miller who was so well qualified to write a History of the Regiment, as well as to revise Kane's List, was obliged to discontinue his researches, the Committee gratefully acknowledge the assistance he has already given them, and hope that his services at some future time may be made available towards the production of the History of the Regiment.

The old Printing Press being worn out, the Committee directed the purchase of a new one, at a cost of £35.

4. *Library.*—Jerden's Birds of India (3 Vols.) have been purchased for the Library, being a good text book upon this subject.

Scientific Opinion and the Anthropological Review are now purchased for the Reading Room.

The Committee will be glad to receive autographs of eminent men, for the collection already commenced, and they have to thank Captain H. Brackenbury, R.A. for his contributions.

There has been a sale of 392 War Office Photographs and 1215 Lithographs during the past year, and lists of those published since the last Report have been sent to Members.

The following books, plans, &c. have been purchased and presented since the last Annual Meeting.

Books, &c. presented.

Hart's Quarterly Army List for January, April, July, and October, 1868	4	R.A. Library, Woolwich.
A Plan of Discipline for the use of the Norfolk Militia, 1759	...	
War Department Photographs	352	War Department.
R.L. Lithographs	7	
R.G.F. Lithographs	4	
R.C.D. Photo-Lithographs	9	

Annual Report of the Ordnance Select Committee, 1867, 8.	3	The Director-General of Ordnance.
Extracts from the Reports and Proceedings of the Ordnance Select Committee, Part 4. Vol. II. 1, 2, and 3, Vol. VI.	6	
Description of Navez-Leurs's Electro Ballistic Apparatus, by Captain W. H. Noble, R.A.	12	
Report of a Special Committee on the Gibraltar Shields	1	
Observations by Col. Jervois, C.B., R.E., on the last-mentioned Report	1	
Addenda to Report of Special Committee on Gibraltar Shields	...	
Report on the Conduct of the War, 1865, Vols. I. II. III. Part 1	4	Captain W. A. F. Strangways, R.A.
Report on the battle of Murfreesboro' ...	1	
Army of the Potomac—M'Clellan	1	
The Peninsular Campaign and its antecedents, by J. G. Bernard	1	
Military Map of Kentucky and Tennessee	1	
Collection of American Military Maps ...	...	
Revised Route Map of Abyssinia	...	The Director, Topographical Department.
Lithograph of Capture of Magdala, 13th April 1868	2	
Lectures on the Construction of Guns, by Olinthus Gregory	13	Maj.-General P. Anstruther, R.A.
Report by the Council of Military Education on the Second Advanced Class of R.A. Officers, 1868	1	The Director of Artillery Studies.
MS. Regulations to be observed, at the Dinner to be given by the Master-General and the Officers of Royal Artillery and Royal Engineers in honor of Her Majesty's Coronation, on Thursday, 5th July, 1838	1	Major R. J. Hay, R.A.
Pamphlet on Portable Arms in the Paris Exhibition of 1867, by Captain. V. D. Majendie, R.A.	1	The Author.
Photo-Lithographs of Abyssinian Equipment, Nos. 1a to 1j	9	The Secretary of State for War.
Lithographic view of Magdala, 2nd Edition	2	
Index to the several Articles in the Periodical Publications received in the War Office Library during the year 1867	2	The Librarian, War Office.
Index to the Periodical Publications received in the War Office Library	2	
Photographic Views from Madras	24	Major B. L. Forster, R.A.
Essay on the Early Establishment of Artillerymen in England, and on other points connected with the Regimental History of the Royal Artillery, by Lt.-Col. F. Miller, VC., R.A.	...	The Author.

Report on Artillery, by Lieut.-Colonel C. H. Owen, R.A.	...	The Author.
Dutch Artillery Works	14	Netherlands Government.
Photo-Lithographs of Dutch Artillery	6	
Dutch Artillery Plates	5	
" Military Works	6	
The Compleat Body of the Art Military, by Lt.-Col. R. Elton, 1668	...	Lieut. F. C. Nicolas, R.A.
An Abridgment of the Military Discipline, 1685		
Proceedings of the Zoological Society, of London, Parts 1, 2, and 3, 1868	...	The Council, Zoological Society of London.
The Trials of William, Earl of Kilmarnock, George, Earl of Cromartie, and Arthur, Lord Balmerino, for High Treason, 1746	...	Lt.-Col. H. Chermside, R.A.
Photographic Views of Abyssinian Route	12	Capt. E. T. Pottinger, R.A.
Colored Print of Sadler's Flying Artillery.	...	Lieut. H. W. L. Hime, R.A.
MS. Books, containing Tables of Ranges, Weight of Shot and Shell, &c., by the late Major Fry, R.A.		
The Mathematical Principles of Natural Philosophy, by Sir Isaac Newton		
Photograph of the Ruins of Garaspur, Central India	...	Lieut. A. B. Cunningham, R.A.
Pamphlet on Field Artillery on the connected system, by Capt. W. A. Ross, R.A.	...	The Author.
The Artillerist's Manual and British Soldier's Compendium, 10th Edition, by Major F. A. Griffiths, R.A.	...	The Author.
The British Army in 1868, by Sir C. E. Trevelyan, K.C.B.	...	The Author.
Russian Artillery Journals	...	Maj.-Gen. N. de Novitsky.
" Engineer and Military, do		
" Small Arms, do		
Naval and Military Memoirs of Great Britain from 1727 to 1783, by R. Beatson, Esq., LL.D	...	Serjt. J. Browne, R.A. Band.
Proceedings of Royal Geographical Society	...	The Council, Royal Geographical Society.
Report of the Examination for admission into the Royal Military Academy, July 1868 and June 1869	...	The Council of Military Education.
The Sculptured Stones of Scotland, by John Stewart, Esq.	1	The Author.
A General System of Attack and Defence	1	J. Hewitt, Esq.
A Treatise on the Art of War	1	
Memoirs of the late Marquis de Fenquieres	1	
Remarks on Cavalry, by Major-General Warney	1	
Professor Bashforth on the Resistance of the Air to the Motion of Elongated Projectiles	...	The Author.

Notes on Boxer Ammunition for Snider converted Rifles	...	Capt. C. O. Browne, R.A.
Monthly Notices of the Royal Astronomical Society	...	Royal Astronomical Society.
Reports of the Paris Universal Exhibition, 1867	4	Society of Arts, Manufactures, and Commerce.
Pamphlet on the application of Hydraulic Buffers to prevent the destructive effects of Railway Collisions, by Col. H. Clerk, R.A., F.R.S.	...	The Author.
Annual Reports of the President Ordnance Select Committee, 1, 2, and 4	...	Maj.-Gen. J. H. Lefroy, R.A.
Narrative of the Campaign of the British Army in Walcheren	1	
Notes on the Viceroyalty of La Plata	1	
North Georgian Gazette of the Northern Expedition under Capt. Parry, by Capt. E. Sabine, R.A.	1	
Smithsonian Contributions to Knowledge, Vol. XII.	1	Smithsonian Institution, Washington, U.S.
Washington Artronomical Observations, 1865	1	
Smithsonian Report, 1866	1	
Lecture on Electrical Measurements	...	The Director, Royal Engineer Establishment, Chatham.
Lectures on Beams, Girders, and Roofs, delivered at the R.E. Establishment, Chatham, by W. C. Unwin, Esq.	...	
Two Lectures on Elementary Acoustics, by W. F. Barrett, Esq.	...	
Lecture on Building Materials, by W. Dent, Esq.	...	
Repository Exercise, for the use of the Madras Artillery, by Lt.-Col. J. H. Frith	...	Lieut.-General B. Cuppage, R.A.
A New Treatise on Artificial Fireworks, by Lieut. Robert Jones, R.A.	...	
The Attack and Defence of Fortified Towns, by J. Muller	...	
Treatise on Gunpowder, by Capt. Thomson, R.A.	...	
Questions and Answers on Artillery, by Lt.-Col. J. H. Frith	...	
Pratique de la Guerre, par Le Sieur Malthus	...	
Historie des deux Triumvirats	3	
Experiments carried on at Woolwich with 8-in. Mortars in 1791–2 (MS.)	...	
Geographia Antique	...	
Book of French Military Maps	...	
A Compendious View of Universal History, from 1753 to 1802, by C. Mayo, LL.B.	4	
Atlas Royal	...	
Terrestrial Atlas	...	
Swiss Artillery Journal	3	Swiss Confederation.

Pamphlet on a Helmet of the 14th Century, &c. by Brigadier-General Lefroy, R.A.	...	The Author.
Remarks on two Pyramid Papers in the last published number of the Proceedings of the Royal Society of Edinburgh, by Piazzi Smyth	...	Mrs A. Benn.
A Geological Table of British Fossileforous Strata, by Sapper W. Parsons, R.E....	...	Professor J. Tennant, F.G.S.
Portrait and Photographs of Memorials to the late Lieut. H. E. Baines, R.A.	4	Mrs Baines.
Examination Papers R.M. Academy, June and December, 1868	...	The Inspector of Studies, R.M. Academy.
Journal of the Royal U.S. Institution ...	...	The Council, Royal U.S. Institution.
Jomini's Art of War	...	Lieut. T. C. Price, R.A.
Ordnance and Gunnery, U.S.M.A.	...	
Ordnance Manual for the Officers of the U.S. Army..............................	...	
Photograph of Abyssinian Trophies	...	Major G. Arbuthnot, R.A.
A Retrospect of the Amalgamation of the Royal and Indian Brigades of Artillery, by Lt.-Col. W. J. Gray, R.A.	...	The Author.
Pamphlet on the Education given at the R.M. Academy, with a few Observations on the Training of Artillery Officers, by Lt.-Col. C. H. Owen, R.A.	...	The Author.
The Distribution of our War Forces, by Capt. J. R. C. Colomb, Royal Marine Artillery	...	The Author.

Books purchased.

Alphabete Orientalischer und Occidentalischer Sprachen. By F. Ballhorn.
A monograph of the Kingfishers. Parts I. II. and III.
An Elementary Treatise on Heat, by Balfour Stewart. One Vol.
Armes de Guerre Etudes sur le Chargement par la Culasse. One Vol.
Army Estimates, 1869, 70.
Burn's Naval and Military Dictionary. Fifth Edition.
Chesney's Waterloo Campaign.
Girdlestone's Arithmetic. One Vol.
Gould's Birds of Asia, Part XX., and Birds of Great Britain, Parts XIII. and XIV.
Hogg on the Microscope.
Jerdon's Birds of India. Three Vols.
Lavallie's Physical, Historical, and Military Geography, by Capt. Lendy, R.E. One Vol.
Military Elements, by Capt. Walker, R.E. One Vol.
Muspratt's Chemistry. Two Vols.
Nautical Almanac, 1869.
Report from the Select Committee on Royal Gun Factories.
Report to the Government of the United States on the Munitions of War. Exhibited at the Paris Universal Exhibition of 1867.
Revue de Technologie et d'art Militaires. Nos. 2 and 3. 1868.

Revue Militaire Francaise. Nos. 1, 2, and 3. 1869.
Siege Artillery in the Campaigns against Richmond.
The British Army in 1868, by Sir C. E. Trevelyan, K.C.B.
The Ibis. Nos. 15, 16, and 17.
The Invasion of the Crimea, by Kingslake. Four Vols.
Treatise on Coast Defence, by Von Sheliha.

Twenty-three second-hand books:—

Cavalry, its History and Tactics, by Capt. S. E. Nolan. Third Edition.
Complete System of the Military Art, explaining the Technical Terms, Works, and Machines used in the science of War, with an Introduction to Fortification compiled from the best writers on military affairs.
Description of the Sights or Instruments for Pointing Guns, proposed by Major-General Sir W. Congreve.
Dictionnaire de l'Artillerie par le Col. H. Cotty, 1822, and supplement, 1832. Two Vols.
Etat Actuel de l'Artillerie de Campagne en Europe, par Jacobi—Artillerie de Campagne Anglaise.
General Essay on Tactics, with an Introductory Discourse upon Military Science in Europe, to which is prefixed a Plan of a work entitled "The Political and Military System of France," translated from the French of M. Guibert. Two Vols.
General Treatise of Artillery, or Great Ordnance, writ in Italian, by Tomaso Moretti, of Brescia, translated with Notes thereon and Additions for Sea Gunners, by Jonas Moore, with Appendix of Artificial Fireworks for War and Delight, by Sir A. Dager.
Histoire des Fusees de Guerre, ou recueil de tout ce qui a ete publie ou ecrit sur ce projectile, suivie de la description et de l'emploi des obus a mitraille dits Shrapnells, et des Balles Incendiaires, par J. Corréard,
James' Collection of the Charges, Opinions, and Sentences of General Courts Martial, from 1795 to 1820.
Le Bombardier Francois ou Nouvelle Methode de Jetter les Bombes avec precision, par M. Belidor.
Manuel de l'Artilleur, par Theodore Durtubie.
Military Studies of Marshal Ney, written for the use of his Officers.
Nouveau Systeme d'Artillerie de Campagne de Louis Napoleon Bonaparte.
Nouvelle Force Maritime et Application de cette Force a quelques Parties du Service de l'Armee de Terre, par H. J. Paixhans.
Pratiche di Artiglieria nelle Manovre di Forza usate ne'movimenti delle diverse bocche a fuoco ed altri pesi gravi di quell' arma.
Precis des Campagnes et des Sieges d'Espagne et de Portugal de 1807 a 1814, d'apres Touvrage de M. Belmus, par M. Augoyat.
Report of Commissioners for Inquiring into Naval and Military Promotion and Retirement, with Appendices.
Samuels' Historical Account of the British Army, &c.
Sir Howard Douglas on the Motives, Errors, and Tendency of Carnot's Principles of Defence.
Theory of Field Fortification, by Malorti de Martemont.
Traite de l'Art de Combattre de l'Artillerie a Cheval reunie a la Cavalerie, par E. Decker.
Universal Military Dictionary.—A copious Explanation of the Technical Terms, &c. used in the Equipment, Machinery, Movements, and Military Operations of an Army, by Capt. Smith.

List of Periodical Publications.

Anthropological Review.
British Journal of Photography.
Comtés Rendus.
Crelle's Journal.
Engineering.
Jackson's Woolwich Journal.
Journal de Mathématiques.
„ des Armes Spéciales.
„ of the Society of Arts.
Le Spectateur Militaire.
Monthly Notices of the Royal Astronomical Society.
Philosophical Magazine.
Proceedings of the Meteorological Society.
Publications of Palæontographical Society.
Scientific Opinion.
The Photographic News.
The Times.

Arundel Society Plates.

The Adoration of the Lamb.
SS. Peter and Paul before Nero, and the Martyrdom of St Peter.
Notice of the Brancacci Chapel, by A. H. Layard, M.P.
The Vision of St Bernard.
The Procession of the Magi.

5. *Museum.*—The Committee regret that during the past year but few birds, have been received, amongst them however there are some of much interest, particularly the (*Serpentarius reptilvorous*) Serpent Eater, and (*Bucorvius Abyssinicus*) Abyssinian Hornbill, presented by Lieutenant W. G. Knox, R.A.

From Abyssinia have also been received the (*Neotragus Saltiana*) Salt's Antelope and (*Gazella Sœmmeringii*) Sœmmering's Antelope, which are rare specimens.

Captain Thurlow and Lieut. Burgess, R.A., have presented some birds from India, and Lieut. Hutchinson, R.A., a few from South America.

It is most desirable to complete the collection of British Birds and Eggs, and the Committee trust members will enable them to place this part of the ornithological collection in a satisfactory state.

In Shells and Insects very little has been done; many families in the former are deficient, and some not even represented. As regards the latter, there are hardly any British specimens, and the Committee trust that members will remedy this deficiency.

Some fossils and minerals, and miscellaneous weapons, have been presented to the Museum.

Presentations to Museum.

2 Bows	From the South Sea Islands.	Lt. W. L. Hutchinson, R.A.
2 Bundles of arrows		
1 Chief's club		
1 Long spear		
1 Paddle		
1 Short do		
2 War clubs		

Knife, Somauli	1	Capt. H. Le G. Geary, R.A.
Spears, Shoa	3	
Swords do	1	
Skin of Small Antelope	...	Lieut, J. P. Nolan, R.A., and Lieut. E. F. Chapman, RHA.
Head of Antelope		
Birds from Peru	10	Mr H. Whitely, jun.
Egg of Brush Turkey	1	Mr H. Whitely, sen.
Piece of the shirt worn by King Theodore at his death, stained with his life blood.	...	Capt. E. T. Pottinger, R.A.
Specimens of Kaffrarian Woods	38	Lt.-Col. H. Chermside, R.A.
Model of Field Gun and Limber	...	Mrs Belson.
Plaster Model		
Sword and two scabbards		
Specimen of Wood (Kauri Pine)	1	Lieut. A. Grubb, R.A.
Piece of Kauri Gum	...	
Piece of fern root, used by the Maories as food	...	
Crystals of sulphur, Piece of wood, imbedded in Silicious Stalactite, Silicious Sinter (from the Hot Lake district of Rotomakund, New Zealand)	...	
Birds from South America	8	Lt. W. L. Hutchinson, R.A.
Hoof of Officer's Charger	...	Capt. W. A. Ross, R.A.
Box of Models for Cavalry Drill		
do do Field Artillery		
Curious Specimen of Dovetailing	...	
Specimen of Goshawk	...	Lieut. T. Griffin, R.A.
Specimens of White Corals		
Silver Coin (six Livres) of the French Republic, 1793	...	Capt. W. R. Kirkman, R.A.
Master-Gunner's Warrant, 1810	...	
Part of a Russian Fuze picked up on the Field a few days after the Battle of Inkerman	...	Lt.-Col. F. J. Soady, R.A.
Indian Model (4 figures) from Lucknow	...	Capt. P. H. Sandilands, R.A.
A gunner's Level	...	Lt.-Col. F. Miller, V.C., R.A.
Copper Plate, bearing an inscription in Hindostani, removed from a large wrought-iron gun which was taken from the rebels at the Siege of Kotah, in March, 1858	...	Major W. Stirling. R.A.
Birds from Abyssinia	3	Lieut W. G. Knox, R.A.
1 dol. and 1000 dol. Notes issued by the late Confederate States of America ...	...	Capt. C. Hardy, R.A.
Paper Fuze used by Confederate Army during the late War		
Matchlock from Abyssinia	...	Lt.-Col. L. W. Penn, C.B., R.A.
Set of Shoes taken off a Persian Horse at Belgaum	...	Lieut. C. E. B. Leacock, R.A.
Collection of Fossils and Minerals	...	Lieut. J. T. Greenfield, R.A.
Specimen of Frog, eaten out by Ants ...	...	Capt. C. J. McMahon, R.A.
Birds from India	7	Capt. E. H. Thurlow, R.A.
Small Collection of Insects	...	

Birds from Canada	2	Lieut. F. B. Russell, R.A.
Collection of Coloured Leaves from Canada		
Musk Rat do	1	
Birds from India	9	Lieut. H. M. Burgess, R.A.
Bottle of Insects, &c.	1	
Butterflies from India	...	
Bones of Bats	...	
Skull of Adjutant	1	
Egg of Scissors Bill	1	
Bark Canoe, two Paddles, and Spear, from Terra-del-Fuego	...	J. Hewitt, Esq.
Pipes of the earliest European form, found in 1869 in an ancient kiln built against the wall of the Palace of the Bishop of Lichfield, battered down in the Civil Wars	...	
British Birds	2	Lieut. T. C. Price, R.A.
Cases of Geological Specimens	4	Mrs Hogge.
Paddle of rude manufacture	...	Lt.-Col. J. Campbell, R.A.
Irish Pike, taken in the riots of Smith O'Brien, in 1848		
Valuable Collection of Arms	...	From the Head-Quarters Mess of the late Bengal Artillery at Meerut.

Presented by Lieut. T. Griffin, R.A., from Morocco.

Astur palumbarius,	Goshawk.

Presented by Lieut. F. B. Russell, R.A., from Canada.

Nyctiardea gardeni,	Night Heron.
Surnia ulula,	Hawk owl.

Presented by Lieut. W. G. Knox, R.A., from Abyssinia.

Buceros,	Pied hornbill.
Bucorvius Abyssinicus,	Abyssinian hornbill.
Serpentarius reptilvorous,	Serpent eater.

Presented by Capt. E. H. Thurlow, R.A., from India.

Copsychus saularis,	Magpie robin.
Cuculus micropterus,	India cuckoo.
Dendrocitta rufa,	Indian magpie.
Garrulus lanceolatus,	Black-throated jay.
Lanius tephronotus,	Grey-backed shrike.
Nuapaga hemispila,	Himalayan nutcracker.
Turtur sinensis,	Spotted-necked turtle.

Also a small collection of insects.

Presented by Lieut. H. M. Burgess, R.A., from India.

Athena brama,	Spotted owlet.
Butorides javanica,	Little green heron.
Erocopus phœnicopterus,	Green pigeon.
Fulica atra,	Coot.
Graculus javanicus,	Little cormorant.
Lanius erythronotus,	Rufous-backed shrike.
Rhynchœa bengalensis,	Painted snipe.
Syphcotides auritus,	Lesser florakin.
Totanus glottis,	Greenshanks.

Also a few shells, insects, and reptiles.

Presented by J. P. Nolan, R.A., and Lieut Chapman, R.H.A., from Abyssinia.

Gazella Sœmmeringii,	Sœmmering's antelope, head only.
Neotragus saltiana,	Salt's antelope.

Presented by Lieut. W. L. Hutchinson, R.A., from South America.

Calliste festiva,	Red-necked tanager.
″ flava,	Yellow tanager.
″ flaviventris,	Yellow-bellied tanager.
″ thoracica,	Yellow-breasted tanager.
″ tricolor,	Green-headed tanager.
Galbula viridis,	Green jacamer.

Presented by Lieut. T. C. Price, R.A.

British.

Alcedo ispida,	Kingfisher.
Clangula glaucion,	Golden-eye.

6. *Taxidermy.*—This class has met regularly, and been very well attended. Sixteen Officers have received instruction since the last Annual Meeting, and several have gained proficiency in the art of setting up birds, as well as the preserving of skins.

7. *Classes.*—The Classes for Drawing, Short Hand, Italian, German, and French have met as usual, and the two former have been well attended.

8. *Surveying and Practical Astronomy.*—During the past year the Surveying Class has been attended by sixteen Officers, all of whom have been instructed in military sketching and measuring distances, Major Drayson having attended twice in each week for this purpose.

9. *Photography.*—The Photographic department is in good working order, and continues to prosper; during the past year 560 negatives have been taken, from which about 6000 copies have been printed.

10. *Chemistry.*—The Laboratory has been in constant use by the Classes of Officers under the Director of Artillery Studies. Voluntary Classes have also received instruction in Chemistry.

11. *Instruments.*—The instrument room is now entirely devoted to Instruments. The Balances, Microscope, Air Pump, and Navez' Ballistic Apparatus, are always ready for the use of members, the first are in much request, being used by the members of the Chemical Class working at quantitative analysis.

The Barometer has been removed from the Secretary's Office to the Reading Room, is set every morning, and a record kept.

The following purchases of instruments have been made since the last Meeting, involving an outlay of £28, viz.:—

Ruhmkorff's Coil, | Tangent Galvanometer,
Spectroscope.

A Navez' Electro-Ballistic Apparatus and ten Cells of Bunsen's battery have, through the kindness of the Secretary of State for War, been deposited in the Institution for the use of members.

12. *Model Room.*—The Secretary of State for War being of opinion that all Stores supplied by the War Department, should be considered as "deposited" for the use of Members, they will in future be borne upon the charge of the P.S. of Stores, Royal Arsenal.

The Committee observe that this arrangement of the Secretary of State is a most advantageous one, as they hope it may enable them to procure direct from the Royal Arsenal, the latest projectiles and other stores in the service, and so make the Model Room one of the most instructive features of the Institution.

A "remain" has been taken of the stores now on charge of the Institution, by an officer of the Military Store Department.

The thanks of the Committee are due to Captain C. O. Browne, R.A., Captain Instructor, Royal Laboratory, for assistance lately given in classifying these Stores.

13. *Lectures.*—Lectures have been delivered weekly in the Theatre of the Institution by Mr Bloxam, F.C.S., on General Chemistry, and by Dr Percy, F.R.S., on Metallurgy.

The following list contains a statement of Evening Lectures which have been given during the past winter; and the Committee have to express their thanks to Mr J. M. Bellew, Mr J. Brandram, Mr W. K. Clifford, and Mr W. Hepworth Dixon. Especial thanks are due to Mr Bloxam for the excellent and entertaining Lectures which he has delivered upon this and former occasions.

J. M. Bellew, Esq.	Readings from various authors.
C. L. Bloxam, Esq., F.C.S.	Chemical Lecture.—Atoms and their attractions.
J. Brandram, Esq.	Readings from various authors.
W. K. Clifford, Esq.	The Intellectual Possibilities of Mankind.
W. Hepworth Dixon, Esq.	Wild Life on the Prairies.
C. R. Salaman, Esq.	English Opera.

Consequent upon the number of changes in the Committee during the past year, it is proposed so far to limit Rule V. as to restrict the number of members who retire by rotation to two, viz:—

Surgeon-Major Combe. Captain W. H. Noble.

The following members having left the Garrison, the vacancies thus occasioned have been filled up by the Committee, subject to the approval of the General Meeting:—

Lieut.-Colonel Gosling,	by	Colonel Rotton.
" Chermside,	"	Lieut.-Colonel FitzHugh.
" Couchman,	"	" F. Miller.
" Miller,	"	Captain T. B. Strange.
Lieut. H. W. Hime,	"	" F. Duncan.

The Secretary, Committee on Inventions, has also sat on the Committee, in place of the Secretary, O.S. Committee, subject to the approval of the General Meeting.

The following resolutions were passed:—

1. *Proposed by Colonel Shaw, seconded by Colonel Phillpotts,*—

"That the Report of the Committee be adopted and printed."

2. *Due notice having been given, in accordance with Rule XVIII., the following alterations in Rule V. were submitted by the Committee and carried:*—

(1) "That the 'Director General of Ordnance' be substituted for 'Director of Ordnance.'"

(2) "That the President and Secretary of the O.S. Committee be erased, these offices having been abolished, and that the Secretary, Committee on Inventions, be substituted for the latter."

3. *Proposed by the Committee, seconded by Colonel Shaw, and carried, that the following addition to Rule II. be made, and to be inserted between 2nd and 3rd paragraphs:—*

"The Committee shall have power to elect as honorary members for short periods Officers of the Army and Navy, who may be temporarily in the Garrison or neighbourhood."

4. *Due notice having been given in accordance with Rule II., it was proposed by the Committee, seconded by Colonel Phillpotts, and carried:—*

"That Captain Moncrieff, Edinburgh Militia Artillery, be elected a Special Honorary Member."

5. The following Officers were elected to serve on Committee, viz:—

Captain J. S. Stirling,

Proposed by Captain Lowry, and seconded by Captain F. A. Whinyates.

Asst.-Surgeon F. R. Hogg,

Proposed by Colonel Wray, C.B., and seconded by Captain Noble.

6. On the motion of Captain T. B. Strange, a discussion ensued on the propriety of Officers and others being permitted and invited to read papers on subjects of professional or of general interest.

The sense of the General Meeting was decidedly in favour of these discussions taking place, but it did not appear necessary to pass any general resolution on the subject, as Rule XVII. already gives power to the Committee to arrange for such readings and discussions.

7. *Proposed by Colonel Phillpotts, seconded by Colonel Shaw:—*

"That the thanks of the Committee be voted to the Chairman."

The Committee for the current year will stand thus:

PATRON AND PRESIDENT:

Field Marshal H.R.H. the DUKE OF CAMBRIDGE, K.G.

VICE PRESIDENT:

The Commandant of the Garrison.
The Director-General of Ordnance.
The Deputy-Adjutant General.

MEMBERS:

The Assistant-Adjutant General.
The Secretary, Committee on Inventions.
The Director of Artillery Studies.
The Brigade Major.

Colonel J. M. Adye, C.B.
„ J. T. Field.
„ G. Rotton.
Lieut.-Colonel H. T. FitzHugh.
Captain J. S. Stirling.
„ T. B. Strange.
„ F. A. Whinyates.
„ C. O. Browne.

Captain C. E. S. Scott.
„ J. C. J. Lowry.
„ G. B. B. Hobart.
„ F. Duncan.
Lieut. A. B. Brown.
„ O. F. T. Annesley.
Asst.-Surg. F. R. Hogg, M.D.

Captain A. D. Burnaby, *Secretary and Treasurer.*

(Signed) A. BENN, Colonel, R.A.,
in the Chair.

19th May, 1869.

ERRATUM.

p. 336, 9th line from top, *for* "varied inversely at its distance," *read* "varied inversely *as* its distance."

THE

NEW FIELD ARTILLERY OF MATTEI-ROSSI.

TRANSLATED FROM

THE ITALIAN

OF "L'OPINIONE," 23rd—26th OCTOBER, 1868,

WITH A NOTE BY THE TRANSLATOR.

BY COLONEL H. H. MAXWELL, R.A.

1. For some time past the new light artillery tried at Foiano has been much talked of. It is well that the country should know the origin of this question, its importance, and the manner in which it has been treated. In 1859 rifled field artillery was first adopted on field service, and its superiority was manifested: at its first introduction not only was the accuracy of fire and effect of the guns very remarkable, but the carriages were so much diminished in weight that the teams were reduced from six to four horses.

All the European powers soon introduced rifled artillery into the armament of their troops, fraught as it was with such important advantages; we alone, from motives of economy and for want of time, contented ourselves with rifling our existing guns, thus in no way altering our *matériel;* by this step the practice was much improved as regards the rifled field gun; and, barring the question of weight, our field artillery was amongst the best in Europe; but due to that one fact of excessive weight, it is inferior to all foreign artilleries.

In the campaign of 1866, the difficulties occasioned by the weight of our artillery became evident, and the necessity of lightening it was acknowledged: but besides the importance of bringing up the *matériel* of our artillery to the degree of perfection obtained among other nations, the introduction of breech-loading small-arms has created anew the necessity of doing so; this we will endeavour to explain.

The quickness of fire of breech-loading arms, and the facts of the Austro-Prussian war have demonstrated that good infantry covers its front by such a mass of fire, as to render any attack against troops so armed materially impossible.

Hence an enemy armed with breech-loaders, who remains on the defensive in action, and upon whom it is necessary to march up to, to come to hand-to-hand fight, is, it may be said, invincible; unless artillery in large numbers, brought into action beyond the range of musketry, plays on him and breaks his formation before attempting to attack him with the steel. In fact, in the Prussian regulations, and in those of other European armies, it is recommended when engaged to remain on the defensive, obliging the enemy to assume the more difficult part of the attack. But it follows and always will follow, that in war, an attack must eventually be made on an enemy hand-to-hand; and he who has to do so, will find that he has a difficult task in hand, unless he has a numerous artillery to break the enemy from beyond the range of the breech-loader. Now, a numerous artillery can only exist on the condition of its being light; otherwise an army would have as many incumbrances and *impedimenta,* as the Romans called it, as would have been scorned by the army of Artaxerxes. Moreover, an armament of artillery so organized would cost the country a ruinous sum, and it would be compelled to purchase, for the teams of artillery of the present pattern, such a number of horses as to render it vain to attempt to form such a mass of artillery.

Such a state of affairs compelled the government seriously to weigh this question, and to endeavour to find the means of solving it.

The reader may thus discern from this rapid glance, that the question is a vital one for the army, and that obstacles cannot and ought not to be permitted to be thrown in the way of its solution; and this all the more at the present moment when the whole of Europe is topsy-turvy, and it may so happen that a war may break out in which Italy must take part.

These short considerations upon the necessity of reforming the armament of the artillery being premised, in order that the reader may be in a position to judge of the new artillery tried at Foiano, we will give a few data connected therewith, comparing at the same time foreign with existing artillery, and thus he will be able properly to appreciate the value of the work done.

Before entering into the question, it will be necessary to give some illustrations of artillery matters, which are indispensable to placing the reader, who has no knowledge of such matters, in a position to comprehend and appreciate the advantages and disadvantages which the new artillery may be possessed of.

A projectile thrown from a gun produces destructive effects upon all substances it may come in contact with; that is, it penetrates and knocks down walls, cleaves and cuts down trees, breaks down palisades, slaughters and wounds men, horses, &c. We note in passing that it is this last effect which is chiefly required in field artillery; nevertheless, a field gun should be capable of breaking down such obstacles as are usually met with on the field of battle, to wit, farm and country houses, slight intrenchments hastily thrown up by an enemy, and the natural defences formed by trees, hedges, and such like. In all cases, the effect alluded to is the product of two elements, viz. of the velocity with which the projectile strikes the object, and of the weight of the projectile itself. It thus appears that we can, without sacrifice of efficiency, diminish one of the two above-mentioned elements (the velocity and the weight of the projectile) provided we increase the other in due ratio.*

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* See note, p. 333.

This premised, we will observe that artillery does not solely consist of the gun and the carriage on which it travels; to these must be added a number of wagons to contain the ammunition for the piece; from the experience of past wars it is calculated, that a field gun should take into the field at least three hundred rounds. Now, if we wish to lighten artillery, it is clear that we must diminish the weight of the projectiles, as those are the more numerous; but by diminishing the weight the effect of the projectiles will naturally be lessened, unless, as we have seen, we can increase their velocity, or in other words, the charge of powder with which the gun is fired.

Rifled artillery under this aspect was an actual retrogression, since, while the smooth-bores fired a charge of one-third of the weight of the projectile, rifled guns fire a charge of one-sixth, one-seventh, or of one-tenth the weight of the projectile thrown, and with us, who have made a step in advance in this respect, of one-fifth of that weight. But, to increase the charge still further seems impossible, and for the following reasons. A projectile in a rifled gun is like a screw in its nut, a screw of very slow pitch; now we can imagine, that if we withdraw the screw from the nut with extreme and increasing violence and velocity, we shall arrive at a point when it will be no longer possible to increase the violence and velocity of withdrawal without injuring the thread of the screw or of the nut, or of both; with rifled guns we have reached that point.

In conclusion then, the state of affairs is as follows:—To lighten artillery and thus make true progress, involves adequate diminution of the weight of the projectile; by diminishing that weight we shall diminish its effect, unless we increase the charge;* to increase that, again, in the manner hitherto employed is impossible; hence the real problem stands thus: How can we fire with a charge of one-third without injuring the grooves of the gun or the studs of the projectile?

To this we must add, that the increase of the charge of field guns is a matter of the greatest importance, as therewith the *probability of hitting* is much augmented, involving all the *advantages of a flat trajectory*. We will now give an explanation of these terms.

A projectile thrown from a gun does not move in a straight line; but as it advances in its flight, it falls below that line; consequently, to strike a certain point at a given distance from the mouth of the gun, we must aim at a point higher than the given object, by a number of feet equal to the fall of the projectile. Thus, in order to illustrate the matter by an individual distance, let us suppose that we want to strike an object 1000 yards from the mouth of the gun, and further that at that distance the projectile falls 100 yards, we must aim 100 yards above the object, and thus we shall cause the projectile, in its flight, to pass through the object we intend to strike.

Hence, to strike a given object we must know its distance from the gun and the fall of the projectile due to that distance. The latter is found by calculation, or still better by proper experiment at each distance: and as we are supposed to know the distance, we can find the fall. But in action,

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* See note, p. 333.

the distance of the guns from the object to be hit is never known, hence that distance has to be judged by sight or with imperfect instruments; thus, there is nothing more probable than an error in such an estimate. But it must be observed that the objects to be fired at have always a known height, so that if the fall of the projectile is not calculated with perfect accuracy, or in other words, if the distance has not been accurately estimated, it may happen, that while we aimed at the centre of the object (that is, calculating the fall so as to strike the centre of the object) we strike either its foot or its upper extremity. Now this is a matter of supreme indifference in action.

Turning then to the supposition we have made, and further supposing that we want to strike an object situated at 1000 yards from the muzzle of the gun and 6 feet in height: supposing once more that we fire at that object with two different guns, having the following fall at the distance mentioned:—

Distances	900 yards.	1000 yards	1100 yards.
Fall of projectile of the 1st gun,	48 feet	50 feet	54 feet.
" " " 2nd "	72 "	77 "	84 "

Supposing now that judging the distance at sight, we estimated it at 900 yards instead of 1000 yards, as it is in fact.

Firing from the first gun we aim at a point 48 feet higher than the centre of the object to be struck; but as that object is situated not at 900 but at 1000 yards, the projectile will fall not 48 but 50 feet; the target will be struck at 2 feet below its centre.

Making the same error in the estimation of the distance with the second gun, we aim at 72 feet above the object; but as the projectile has fallen 77 feet, it must pass 5 feet below the centre of the target, that is, at 2 feet below its lower edge; hence the object will not be struck. Now, as the same error has been supposed to be made in both instances,—the guns being supposed to fire with the same degree of accuracy or that one gun shoots as well as the other—the two guns give very different results: for with the one, despite the error, the target is struck, while with the other the object will not be touched. Suppose, then, that the fall of the projectile is very small, this will have the effect of making the difference of fall at two adjacent distances trifling; and granted that projectiles can be made which may be thrown at a high velocity, *i.e.* with high charges: this will be the immense advantage gained by the new guns. This reasoning is so true that in the new instructions of the Prussian army it is laid down that rifled guns should be fired at *long* ranges, for at such their accuracy of fire makes them advantageous, as the fall of the projectile, for reasons which it is unnecessary to enter into here, is less than that fired from the smooth bore; while at *short* ranges the latter species of ordnance is to be used, for accuracy of practice at such ranges is of less importance as the fall of the projectile is less than that fired by the rifled gun. Practice when the fall of the projectile is small is said to give a *grazing* fire.

A charge of one-third of the weight of the projectile, that is in the same ratio as the charges of the smooth-bore guns, introduced with this new gun results in uniting the grazing fire of the old artillery (the fire of the new gun is much more "grazing" than that of the smooth-bore) with the accuracy of the rifled gun; a combination which in action is of enormous advantage.*

2. The difficult problem above-mentioned was solved in the most happy way, although it was one that not only nobody in Europe had the courage to undertake the solution, but was held by everybody to be insoluble.

The solution of this question has rendered it possible to reduce the weight of the projectile from 4½ kilogrammes (10 lbs.) to 2·1 kilogrammes (4·63 lbs.); and thus by that sole fact each gun, with its 300 projectiles which it takes into the field, has been lightened by 750 kilogrammes (15 cwt.); and despite of that, the effect of the shot, thanks to the increase of charge, is greater than that of any existing artillery.

Experiments have effectively demonstrated that firing the new and old guns, under identical circumstances against stone walls, the new guns had the greater penetration.

Firing a large number of rounds at a large upright target at a known distance, it resulted that the area of the target enclosing all the shots from the new gun was equal to one-fourth of the area similarly enclosing those of the service gun; consequently the new gun shoots four times more accurately than the service gun.

But besides the above diminution of weight, which may be termed capital, it naturally involves diminution in other respects.

The gun can be made lighter: all the wagons, in consequence of the weight to be carried being smaller, can be made lighter; and, finally, the great progress made in the last few years in iron-construction enables us to obtain, with comparatively lighter weights, an amount of strength which may well be said to be above proof.

Moreover, the substitution of iron for wood in the *matériel* of the artillery is very advantageous from other points of view. In the first place, timber ever perishes, whence it is calculated that the service carriages of the artillery do not last more than eight years; thence it follows that every year we have to renew one-eighth of the *matériel* of our field artillery. Now the value of the existing artillery is about four millions of lires or francs (£160,000) without counting guns; it comprises about 4000 carriages at 1000 lire each (£40), consequently to renew one-eighth every year 500,000 lire (£20,000) must be spent. We may calculate without fear of error that iron carriages will last at least three times as long as those of wood, thus the money spent in renewals will be reduced from 500,000 to 166,000 lire (£20,000 to £6666). Besides, construction in wood involves a handsome stock of that material, so as to be certain that when it comes to be used that it is sufficiently seasoned. On the other hand, iron in these days may be procured at the moment it is wanted for use; it is not necessary then to have capital in a form which gives no interest and which in some cases may be lost altogether. The use of wood in such constructions further involves having large storehouses made in a form specially adapted for ventilation to receive the rough timber and the carriages made of it. The use of iron saves such costly buildings.

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* See note, p. 333.

Finally, there is another matter, which has been but little observed and which could only have been discovered by the eye of an expert; it is that an improvement has been introduced in the method of action of the grease used for lubricating the wheels, and in the manner of attaching the latter to the carriage; by these means, with equal weights the pull and consequently the fatigue of the horses is diminished.

In this manner the following result has been attained:—1st, That the carriage on which the gun rides with its 70 rounds of ammunition weighs a little more than 1000 kilogrammes (19·7 cwt.); if loaded with only 30 rounds it will weigh less than 900 kilogrammes (17·7 cwt.). 2nd, The ammunition wagon with 180 rounds weighs 1100 kilogrammes (21·7 cwts.), and with 90 rounds it weighs under 900 kilogrammes (17·7 cwt.). In the first case, when the wagon contains a large number of rounds, it is intended to be drawn by four horses; in the second case, by only two. Thus there may be two systems of draught, either of four or two horses. In an article in the "Exercito" newspaper, re-published in "L'Opinione" and other journals, the reasons for preferring a 4-horse draught have been given; it is therefore unnecessary to go over the ground again. The statements made in that article are most true: it should, however, be added, that the difference between the 2 and the 4-horse draught lies solely in the fact that in the former case the ammunition boxes are not quite full of ammunition, while in the latter the boxes are as full as they can hold. This being stated, it is evident that a change from one system of draught to the other is one of extreme simplicity, as there is nothing more to be done than to put in an extra pair of horses and to fill up the boxes to pass from a 2-horse to a 4-horse draught.

This being so, we may observe that, in a country like ours, wherein it may be said that draught horses for the artillery are not to be had, the question of passing from the peace to a war footing is one of serious difficulty, and the solution of this difficulty has long occupied the attention of government, for it requires a considerable time to purchase the 12,000 to 15,000 draught horses necessary to put the artillery on a war footing. Now, if the country were taken unawares, it could only buy a portion of the horses required, and hence at the opening of a campaign, it could not appear in its full force; this, in modern warfare is a matter of vital importance, for the wars of the present day are of very short duration; it may be said that they consist of one, or a very few battles, at which it is desirable to deploy the whole force of the country; as, if victory is the result, we are soon masters of the situation; if defeat, we are at once at the mercy of the enemy.

Now, there is no difficulty in seeing at the first glance the immense advantages of an artillery which, with equal power, requires fewer horses; but more than that, if the full number of horses cannot be had, we may meet the first blow with artillery drawn by two horses, without keeping up a large reserve, and without that complete provision of ammunition deemed necessary for a campaign. Thus, the 2-horse draught should not be looked upon as the service footing of the artillery; it may be considered to be a transition formation which would render it impossible for an enemy to surprise the country unarmed, and this attribute is one of the great advantages of the new artillery.

3. Having then in general terms described the new artillery, we will compare it with the service artillery, and with that of divers European powers. Without entering into minute details we will once more repeat, before entering into the question, that it results from the experiments which have been carried out that a round from the new gun has a greater effect than one from the old gun, and at least as great an effect as one from any one of the guns, actual or possible, of Foreign powers, according to the principles which are now admitted to obtain.

In the second place, working the new gun is much more simple than that of any other gun whatever; hence it requires fewer men than does the service artillery, and not more than are employed by all Foreign artilleries; thus this new artillery has the advantage, which may be said to be immense, of affording superior power with a smaller development of means.

Admitted the greater effect of one round of this artillery, we will give the reader the few figures following in support of what we have above stated:—

	New Italian.	Service Italian.	British.	French.	Prussian.	Austrian.
Guns	12	6	6	6	6	8
Wagons	30	21	31	30	16	23
Men	195	185	220	198	152	160
Horses	154	138	244	164	125	117
Rounds carried per piece	260	210	214	240	140	156
Infantry cartridges carried per battery	none *	84,000	102,960	75,600	none *	none *
Weight drawn by gun-team cwt.	19·7	39·4	39·4	25·6 to 27·6	30·5 35·9	23·6 to 27·6

From this aspect it appears that the battery, in point of power, is more than double that of all other European batteries, whilst as to men, horses, and means generally, it is within the limits of all batteries now existing in Europe.† As to facility of manœuvring, thanks to the smaller weight of the carriages, it is far in the way more handy than all other European batteries. This again involves a fresh advantage, viz. that of enabling us to make use of smaller and consequently less expensive horses, and to be dependant solely on those obtainable in the country. But in the present financial difficulties, it would appear to every one a most absurd proceeding to embark in the enormous expense of constructing all this new *matériel;*

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* According to the organization of this battery the transport of small-arm ammunition is not entrusted to it: to compare it with the other batteries on equal terms, we must add 3 wagons, 10 men, and 12 horses for the transport of 84,000 cartridges. But in all artilleries a number of rounds, sufficient to bring up the total to 300 rounds per piece, are carried in wagons not attached to the batteries. Thus the new artillery will have only 40 rounds in those wagons, while the service Italian artillery will have to take into the field 90, the British 86, the French 60, in addition to those with the battery. From this point of view the new artillery is in a better position than the others to which we have compared it.

† See note, p. 333.

and, in truth, this difficulty at first sight may seem insuperable; but on looking closely into the matter, we must allow that the new *matériel* would have the effect of saving so much money in the War Budget, that the cost would be paid off in two years, and that we should gain greatly were it necessary to put the army on a war footing.

In fact, the cost of the new equipments, calculated at an extravagant rate, does not amount to three millions (£120,000), whilst, by somewhat altering the organization of the artillery and of the train, it will effect a saving of more than one million (£40,000).

Moreover, we may observe that the organization of Venetia and its entrenched camp, forces us to spend no small sum in the armament of all these new fortifications. The service field artillery with all its *matériel* would perfectly well serve this end, therefore the introduction of the new *matériel* will evidently diminish by three or four millions (£120,000 to £160,000) the expenditure necessary for the armament of the new fortresses. Hence it may be said that the new artillery will not cost one penny to the country, whilst it will effect an enormous saving to the Budget of the War Department. But to put the case at its worst, the service artillery must always be worth something even if it be sold for old iron; that value, which is more than a million (£40,000), must always be deducted from the three millions (£120,000), the cost of constructing the new *matériel.*

Finally, putting the army on a war footing, and supposing it to remain on that footing 150 days, which is below the truth, and that the new *matériel* effects a saving of 3000 horses and 5000 men, we shall save 2,100,000 lires (£84,000) in the purchase of horses, 900,000 (£36,000) in their keep, and 825,000 lire (£33,000) in the pay and keep of the men. In sum total then we shall save 3,825,000 lire (£153,000), so that in one campaign the new *matériel* will be more than paid for.

After all that we have said, it is clear that,—

(1) The new *matériel* is the lightest of all the existing artilleries, it is consequently the best suited to overcome speedily all difficulties of ground.

(2) As regards power for an equal number of rounds, it is not inferior to any, and is perhaps superior to all.*

(3) As regards power for an equal expenditure of means, it is certainly far in the way (about twice) superior to all European artillery *matériel.*

(4) It is less expensive than the service *matériel,* requires far less repair, besides lasting much longer.

(5) We have no large and special storehouses to construct for storage of the *matériel,* nor for building the carriages is there any necessity of having a large stock of *matériel,* constituting inert and unfructifying capital.

(6) Its adoption will cause a considerable saving in the War Budget.

(7) The new *matériel* will be fully paid for, if it be necessary to put the army on a war footing.

(8) In short, its adoption will increase the force of the nation, saving expense at the same time.

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* See note, p. 333.

The reader, who sees the importance of the above-mentioned advantages, will perhaps wonder at hearing that the new *matériel* is not yet adopted; there are certain reasons for that which we will endeavour to explain.

In the first place, it is proper to say, that the experiments necessary to put in a clear light the above-mentioned advantages are not yet finished in the official, not to say solemn, manner which is necessary to put the matter beyond dispute; but that difficulty will soon be got over. The more serious difficulty to be conquered is that which arises from the nature of man; and in truth a novelty such as that we have before us in artillery, could not but be combated by many, more especially by some technical men who do not, in these novelties, appreciate at their true value the principles upon which they are based, and who thus see their own theories go down like houses built of cards.

In the second place, there are persons who never will admit anything in this world to be good unless it is made by themselves.

These naturally combat every proposal or invention unless it is their own: further, there are people so wedded to form and so little to substance, that such things, however good they may be in themselves, have no value whatever unless they have been anointed all over with the sacrosanct oil of bureaucracy. All these people raise objections and propose difficulties, which, in a matter of such moment cannot but have influence on the military authorities who have to judge in the question. That authority is consequently bound to see that every objection is met by facts, and the collection of these facts requires time, money, and labour. Nevertheless, as this will put the properties of the new *matériel* into brighter light and will end by rendering its advantages indisputable, no great harm will result, unless it is productive of unnecessary delay.

But where the interests of the country are involved, we cherish the hope that this delay will be trifling; for these cannot be allowed to depend upon any private interests, nor upon any miserable fancies of those, be their position what it may, who may endeavour, but cannot and ought not to be allowed, to avail themselves of their position to compromise the interests of the country.

We hope, nevertheless, that the Ministry will gain the honour to its own administration of having introduced such great changes in the artillery and thus render great service to the country. It will, consequently, best know how to overcome all the difficulties which may present themselves.

NOTE BY TRANSLATOR.

The writer of the above article, with all due deference, has fallen into an error not unknown in England. If the projectiles fired by modern field artillery were solid, the whole train of his reasoning would be, in my opinion, perfectly sound. But precisely the reverse is the case: solid projectiles are not to be found in the wagons of any existing field artillery. Nowhere in the text is the effect of the bursting of any hollow projectile considered, much less taken into account. The proposed gun is no more than a musket on a large scale, like Marshal Saxe's "Amusette;" and the effect of its projectiles cannot be compared, when firing at troops in the open, with those of a 9-pr., firing shrapnel at a range of 1200 yards at four targets, 20 yards apart, 54 feet wide and 9 feet high, and making 76 hits per round.*

At the same time a fairly flat trajectory is of the greatest advantage, as the errors in estimation of the distances are of less importance, and as the destructive matter of the burst projectile flies further forward, since a flat trajectory is the result of a high velocity.

The fact is a compromise must be come to between the advantages obtainable by a flat trajectory and those by capacity of shell.

Considering the number of rounds which a battery, it is generally supposed, must carry, and the total consequent weight to be drawn by the teams, I think the calibre should not be under 3 inches, nor the projectile weigh less than 9 lbs.

To the above I can add the following information with respect to the above-described experimental artillery:—

Calibre of the gun	2·559 inches.	
Length of bore	66·89 〃	
Weight of shell	4·63 pounds	$\frac{1}{3}$.
〃 〃 gun charge	1·54 〃	
〃 〃 bronze gun	5·3 cwt.	
〃 〃 steel 〃	3·93 〃	
Initial velocity	1706 feet per second.	
Preponderance	nil.	

Up to the middle of May, 1869, no decision had been come to, but there was a probability of increasing the calibre to 2″·75.

H. H. M.

11th June, 1869.

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* Vide "Standard" newspaper, 19th May, 1869.

THE THEORY OF GUN ARCHITECTURE.

BY

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When rifled ordnance first came into fashion and the artillery service required guns in which the maximum of strength would combine with the minimum of weight, inventions good, bad, and indifferent poured into the War Office, and the proposers generally adduced theories in support of their several systems. Mathematicians, too, turned their attention to the problem, so that altogether a good deal—judging by quantity—has been written and spoken on the subject of late years. The present paper is an attempt to explain briefly the science of constructing guns, and to shew by reference to modern artillery how far theory is carried out in actual practice:—

The power of any homogeneous tube or cylinder to resist pressure from within is not proportional to its thickness. A cylinder for an hydraulic press with a thickness equal to half the diameter of the piston is said to be nearly as strong as one ten times as thick.* Guns are no exception to the general rule. The sides of the 13-inch S.S. mortar are twice as thick as those of the 13-inch L.S. mortar, but the former piece is far from being twice as strong as the latter.

Several men of science who investigated the problem agree that NO POSSIBLE THICKNESS CAN ENABLE A CYLINDER TO BEAR A CONTINUAL PRESSURE FROM WITHIN GREATER ON EACH SQUARE INCH THAN THE TENSILE STRENGTH OF A SQUARE INCH BAR OF THE MATERIAL, that is to say, if the tensile strength of cast-iron be 11 tons per inch no cast-iron gun however thick could bear a charge which would strain it up to that point, for on the first round the interior lamina would be ruptured before the outer portion could come into play, and every succeeding round would tend to magnify the evil.

The matter is not difficult to understand. Take for example a section of the 10-inch cast-iron gun where the thickness of the metal is 5 inches, and assume that the amount which the metal will stretch before it breaks is a thousandth part of its length. Now supposing a pressure could be communicated with

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* Holley. Ordnance and Armor, p. 238.

undiminished force throughout the mass, it is plain that when the circumference of the bore would be stretched a thousandth part of its diameter, *i.e.* the hundredth of an inch, the lamina an inch further would be only stretched $\frac{10}{12}$th of that amount, and the lamina an inch further still only $\frac{10}{14}$th, and so on to the external lamina which would be only stretched $\frac{10}{20}$th or $\frac{1}{2}$ the amount, that is, when the interior of 10 inches diameter would be on the point of rupture the exterior of 20 inches diameter would have only half the strain on it which it could bear. Hence, we might lay down the law that the resistance of each lamina varied inversely at its distance from the axis; but every one knows a pressure is not transmitted with undiminished force through any solid, but that it rapidly decreases as it travels forward, and therefore that the opposition which the exterior is called upon to supply must be less than that deduced by the foregoing law. In fact, the resisting power of the material as well as the distance from the axis must be taken into consideration.

According to the late Professor Peter Barlow, F.R.S., the power exerted by the different parts of a metal cylinder varies inversely as the square of the distances of the parts from the axis; in other words, the strains (σ and s), on any two laminæ are inversely proportional to the squares of their radii, (ρ and r),

$$\frac{\sigma}{s} = \frac{r^2}{\rho^2}.$$

Dr Hart, Fellow of Trinity College, Dublin, having taken into account the compressibility of the metal, which Barlow appears to have omitted, calculated that there is a greater strain on the exterior. His formula may be written thus,

$$\frac{\sigma}{s} = \frac{r^2}{\rho^2} \frac{R^2 + \rho^2}{R^2 + r^2}.^{*}$$

R and r being the external and internal radii, ρ the radius of an intermediate lamina of which σ is the strain, and s the strain on the inside.

If we want to compare the strain on the inside with that on the outside, $\rho = R$, and we have by inversion,

$$\frac{s}{\sigma} = \frac{R^2 + r^2}{2r^2}.$$

In the case of the 10-inch gun before referred to, the strain on the interior compared with that on the exterior, would, according to Barlow, be as 100 to 25, or 4 times as great, but according to Hart only as 125 to 50, or $2\frac{1}{2}$ times as great. But whatever be the exact law of resistance it is evident that the strength of a homogeneous gun is not in proportion to its weight, and that A GUN SHOULD IF POSSIBLE BE CONSTRUCTED IN SUCH MANNER THAT EACH PART OF ITS MASS WOULD DO ITS DUE PROPORTION OF WORK AT THE INSTANT OF FIRING.[†]

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[*] Palliser. Treatise on Compound Ordnance, p. 38.

[†] This principle was, I believe, first enunciated by the late Captain Blakeley, R.A.

This principle is partially carried out:—

In ARMSTRONG'S B.L. guns by giving, through means of shrinking, greater tension to the outer coils than to the inner ones, so that the former do a certain amount of work in compressing and energetically supporting the latter, and still more in his M.L. guns by the employment in addition of a stronger material (steel) for the inner barrel.

In WHITWORTH'S, where a similar effect is produced by forcing on the outer tubes by hydraulic pressure.

In PALLISER'S, by making the barrel of a stronger material than the outside.

In the RODMAN plan of casting adopted by the United States in which the hollow casting is cooled from the interior, so that the inner portion is compressed and supported by the contraction of the outer portion around it.

The last method approaches nearest of all perhaps to the fulfilment of the principle as the metal becomes gradually stronger and stronger from the outside to the bore, whereas in all the other systems the strength of the metal does not progress gradually by regular increments but *per saltum* according to the number of parts superimposed. Unfortunately, however, cast-iron even though thus scientifically disposed is naturally too weak and brittle as a material for rifled ordnance; but it is not impossible that safe, powerful and cheap guns may yet be made in this manner of an improved description of steel.

To Sir William Armstrong is due the merit of employing wrought-iron coils shrunk together. His main principles of gun architecture consist essentially:—

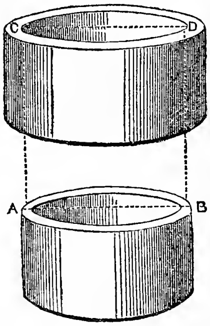
First, In arranging the fibre of the iron in the several parts so as best to resist the strain to which they are respectively exposed; thus, the walls or sides of the gun are composed of coils with the fibre running round the gun so as to enable the gun to bear the transverse strain of the discharge without bursting, whilst the breech end is fortified against the longitudinal strain, or tendency to blow the breech out, by a solid forged breech-piece with the fibre running along the gun.

Secondly, In shrinking the successive parts together so that not only is cohesion throughout the mass ensured but the tension may be so regulated that the outer coils shall contribute their fair share to the strength of the gun in accordance with the theory already explained.

With regard to the first principle a gun may be destroyed either by the bursting of the barrel or by the breech being blown off. Now, wrought-iron in the direction of its fibre is about twice as strong as it is in the cross direction, hence the best way to employ it to resist the transverse strain is to wrap it round and round the piece like a rope. This is the foundation of the Armstrong coil system. For the same reason the best way to resist the longitudinal strain is to place the fibre lengthways or end on; so a breech-piece was made from a solid forging with the fibre in the required direction.

To explain the second principle it will be first necessary to define the terms "shrinkage," "tension," and "compression," as here employed.

When two coils are prepared for shrinking, that is, when their surfaces which are to be in contact are brought to their proper dimensions and to the necessary degree of smoothness, the excess of the exterior diameter *AB* of the inner one above the interior diameter *CD* of the outer one, both coils being cold, is termed the "shrinkage."



In order to shrink the two together, the outer coil must be expanded by heat* until it is large enough to drop over the inner one where it is allowed to cool and contract. Now the power of heated metal to resist contraction is less than that of cold metal to resist compression to a certain point and to a certain point only, hence the inner coil becomes compressed in the process, and the amount its diameter *AB* is decreased thereby is called the "compression," whilst the outer one remains partially extended, and the amount by which its diameter is thus increased beyond its original and natural length *CD* is its "tension."

The shrinkage is equal to compression *plus* the tension, and the amount must be regulated by the known tension and compression under certain strains and circumstances.

The tension on a coil when shrunk on should in no case exceed that due to the elastic limit of the iron. The elastic limit of bar iron is about 12 tons per square inch and causes an extension of about $\frac{1}{1000}$th of its length,† any weight beyond this would stretch the iron permanently and

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* 500 F. is quite sufficient; this will allow a working margin of expansion beyond the amount calculated, so that the iron need never be raised to the high temperature at which scales form.

† The amount of elongation varies not only on the quality of the metal, but with the size and shape of the specimen tested. The specimens tested in the Royal Gun Factories' machine are two inches long and stretch from ·003″ to ·004″ at the limit of elasticity, but from the experiments quoted by Mr Kirkaldy (Experiments on Wrought-iron and Steel, p. 66) made from a bar of iron

weaken the fibre. Hence the tension on no coil should exceed $\frac{1}{1000}$th of its diameter.

The compression varies inversely as the density and rigidity of the mass, the first layer of coils will therefore undergo more compression than the second, and the second more than the third, and so on. Accordingly, in the Armstrong or original construction, a greater proportion of shrinkage was given to the inner layers than the outer, because so much of it was absorbed by compression. The shrinkage, however, never exceeded ·002 per inch of diameter.

The position of the coil must be also considered. The shrinkage over the seat of the charge is greatest of all, as that part of the gun must be the strongest and firmest, whilst the shrinkage over the muzzle is the least, for an opposite reason.

Add to all the foregoing conditions the expediency of shrinking on the several parts so that each shall do its proportion of work on the discharge of the piece (according to a law not exactly known), and it will be seen that the problem is a very difficult one to solve in practice. Indeed, Sir William Armstrong, who introduced the system, has admitted that he did not carry out his plan with theoretical precision, but that the coils were simply shrunk together sufficiently to secure the stability of the fabric and that a small variation was immaterial.* His primary object therefore was to secure cohesion throughout the mass, and in doing this within the limits of shrinkage before stated, he built up his gun to a certain extent in accordance with theory.

It is at all events certain that by a combination of his two principles, one of Sir William Armstrong's guns is considerably stronger than a gun of the same shape and weight would be if made out of a solid forging like the Horsfall gun.

The Woolwich guns built on his system and lined with toughened steel, are sound and strong, but from the fine iron used and the great number of exquisitely finished coils and a forged breech-piece, their manufacture was very costly; and as it was probable that several heavy guns would be required, the War Office pointed out the desirability of procuring some cheaper plan. Accordingly the attention of the Royal Gun Factories was devoted to the question, and their efforts have been crowned with success. First, a cheaper iron sufficiently strong for the exterior of the gun was obtained, and secondly, the plan, which was proposed by Mr Fraser, the principal executive Officer of the Department, was found to be less expensive than the original one.

Mr Fraser's plan is an important modification of Sir W. Armstrong's, from which it differs principally by building up a gun with a few long double or triple coils, instead of several short single ones and a forged breech-piece. There is less material, less labour, and less fine working, and consequently less expense required for the "Fraser" or present service construction.

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10 feet long and 1 inch square, the extension was only $\frac{8}{100000}$ of the length, for every ton, per square inch of section up to the elastic limit, after which it rapidly increases up to the breaking strain.

* Report on Ordnance, 1863, p. 162. "Construction of Artillery," Inst. Civil Engineers, 1860.

With respect to theory it may be urged in its favour, in the first place, that a forged breech-piece (which is a comparatively expensive article and liable moreover to fly into fragments should the gun burst) is not required with a solid-ended steel barrel and long thick coils, although it is absolutely necessary with several short coils to compensate for the longitudinal weakness of their several joints. And in the second place, that if a series of thin coils help us to distribute equally the induced strain on a gun by shrinking on each coil separately, the method is open to the serious objection that it is practically difficult to calculate the respective proportionate amount of tension, and consequently the greater the number of pieces in a gun, the more likely some weakness will exist in the mass owing to the undue strain on some of the parts; for instance, a 13-inch gun of original construction, (Experimental No. 300), split some of its outer coils while the interior ones remained uninjured, thus clearly proving that there was too great strain on the former. Shrinking on the coils successively was adopted by Sir William Armstrong as a convenient mode of adhesion and not on the distribution theory, which was subsequently enunciated. In the formation of a triple coil it is generally a manufacturing necessity to have the first coil cold before the second bar is wound on, but the third bar is wound on while the second coil is hot; the second and third layers therefore cool and contract simultaneously, and are kept in a state of tension by the first which they compress to a certain degree. So here also the theory may be carried out, for assuming that iron expands irrespective of its density the three layers could not recover their natural condition on subsequent heatings.

Thus far for theory, but practical men will be glad to learn that searching and comprehensive experiments have taken place with guns on the new or present service construction, and that the results show beyond all doubt that it is as strong, if not stronger, than its original type.

These experiments, together with the details of the present construction of our heavy guns, will be described in a future number.

AUSTRIAN MOUNTAIN ARTILLERY,*

TRANSLATED FROM

THE GERMAN.

BY HENRY HAMILTON MAXWELL,

LIEUT.-COLONEL R.A. AND BREVET COLONEL.

TRANSLATOR'S PREFACE.

The first edition of the work by the author on the subject of Field and Mountain Artillery was published in 1864; that is, shortly after the adoption of the present Austrian system of Artillery in 1863. A second edition, containing important alterations in *matériel,* was published in the early part of 1868.

The subject of mountain artillery is a specialty of the arm, the knowledge of which is confined to very few British artillerymen. The interest in this branch of the profession has of late years been stimulated by the Bhootan, Huzara, and Abyssinian campaigns. I confess to have been, like most of my brother officers, deplorably ignorant on the theory of the subject until within the last few years, when the subject cropped up; and of the practice, I am utterly so to the present moment.

Even with these disadvantages, I have thought that the experience of Austria, *the* Great Power of Europe which has, I believe, the largest mountainous area within its frontiers, might be of interest to British artillerymen generally, though introduced to them by one who confessedly has but little knowledge of the special branch of the profession treated of.

I can go so far as to say even with my limited knowledge, that the saddling and lading of a mule, so that the animal shall carry his burden daily for, say, a month's march over a mountainous country without

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* By Friedrich Müller, Captain I. and R. Austrian Artillery Staff. Second Edition, Vienna, 1868.

saddle galls and without the load giving endless trouble on the line of march is an art in itself, attainable only by long practice and a clear understanding of the subject. I think some of the details of packing in these pages will be of assistance to those who have to undertake the task.

The weight of the gun and its appurtenances, the calibre of the piece, and the weight of the projectiles of the Austrian mountain gun so nearly approach those of one of the patterns of mountain guns of the British service, that I imagine this translation may be of some use in judging of our own system or systems, which I believe to be only provisional.

The work I have translated from combines field and mountain artillery. In the text on the latter subject are frequent references to what had been detailed on the former as equally applicable. I have therefore in the translation added from the text what was necessary to make it a complete treatise on the subject of mountain artillery.

A great deal of it will be found to be elementary; but in my opinion the elements are well exhibited, and the abstract doctrine everywhere sound; and it is always of use to those well acquainted with the theory of artillery to look at the subject from another man's point of view. To those who are not so learned, I believe a study of what the author has to say will put him in possession of a fair amount of erudition.

As to the translation, I think it well to state that I have rendered the text into English directly from the book; I have then closed the book and endeavoured to put the rough draft of the translation as far as possible into English idiom, in the form of a paraphrase; but in such fashion that the translation will, I hope, be found to contain the substance.

I have been compelled to combine English terms to get equivalents for many of the German technical terms which are unknown in the English technical language; but I comfort myself with the knowledge from good authority that the coinage of technical terms of any art or science is no outrage to a language; and I hope that this will plead my excuse with the reader when he comes on a term which explains itself, but to which his eye and ear are unaccustomed.

All the Austrian weights and measures of the original have been carefully converted to British imperial equivalents.

Through the intervention of a friend, and the kindness of the Austrian War Office, I am enabled to add several valuable drawings explanatory of the text, in addition to those in the original work.

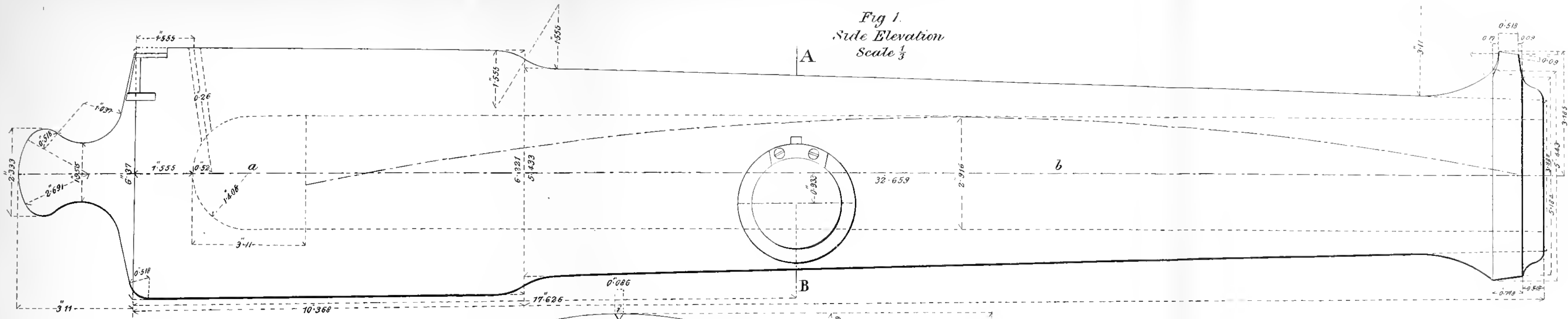
H. H. M.

BLACKHEATH,
June 26, 1869.

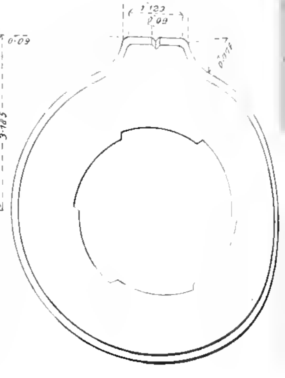
3 Pr. M.L. MOUNTAIN GUN (BRONZE)

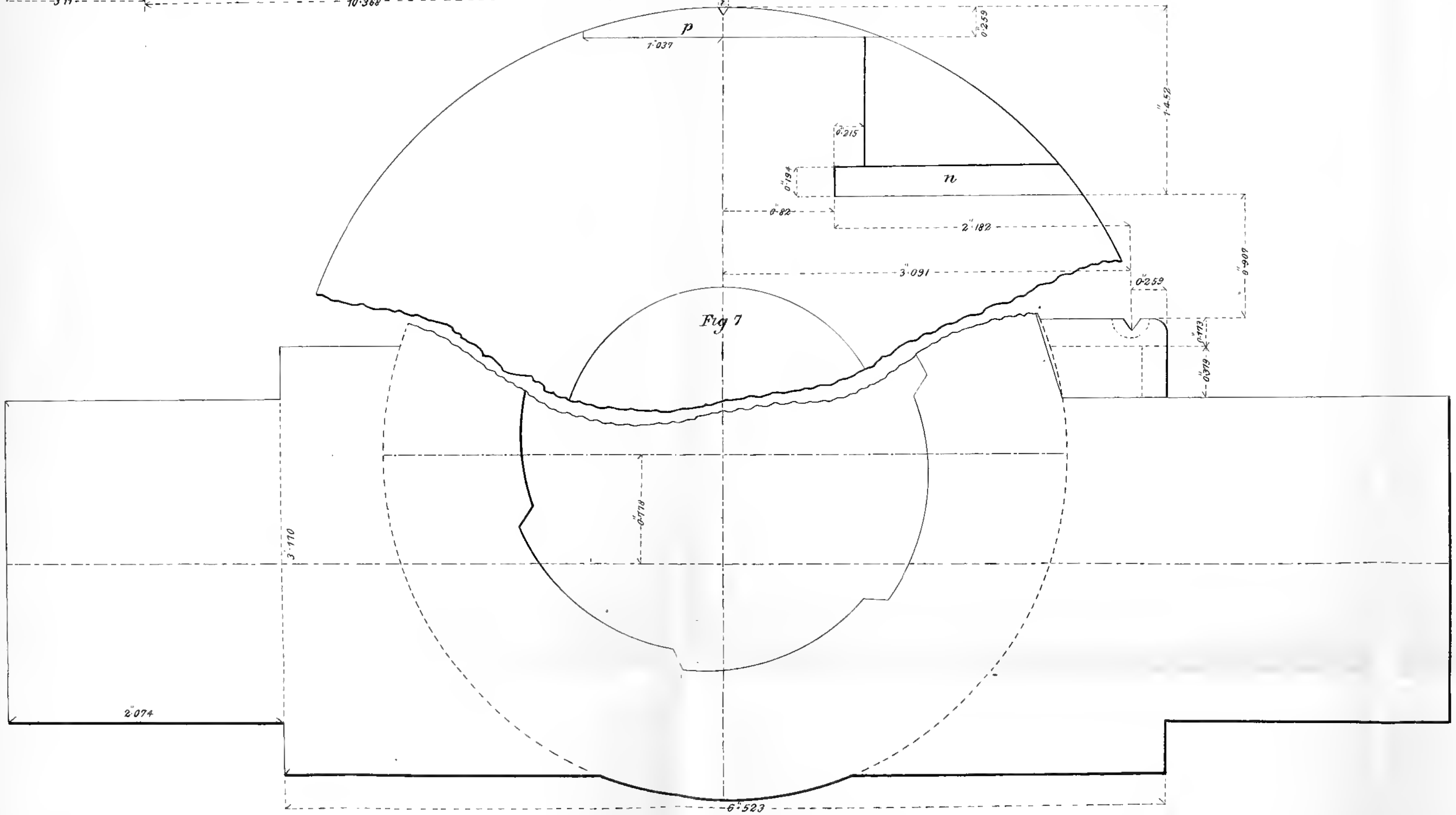
PATTERN 1863.

Fig 1.
Side Elevation
Scale 1/3



Front Elevation
Scale 1/3

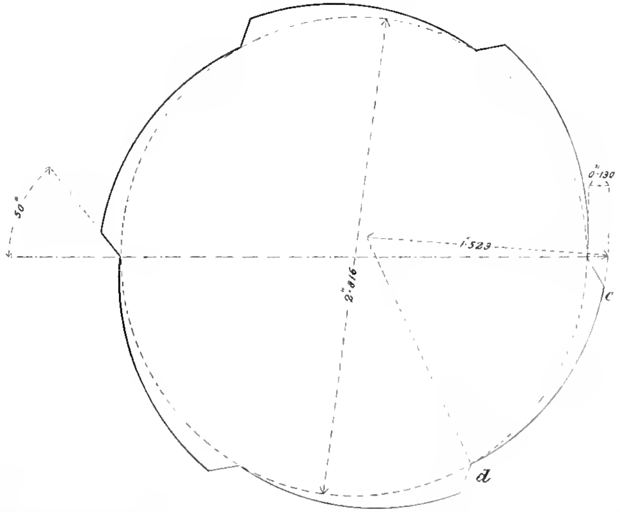




Cross Section on A B & tangent Scale seat

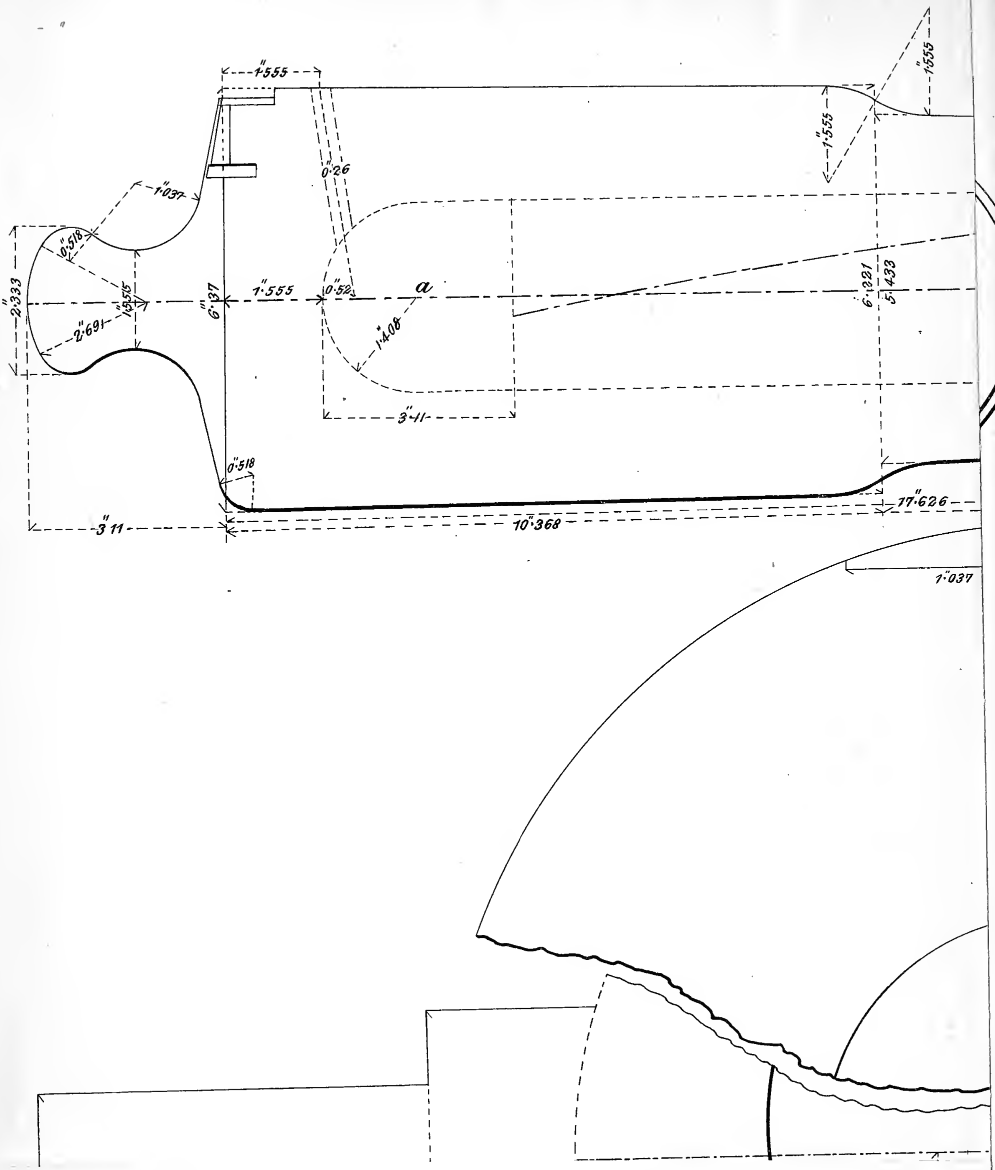
Fig 2.

Bore at muzzle face
full size



Note–Weight .... 191·4 lbs
Preponderance 1/4 weight of gun 46·9 "
Angle of twist of Rifling 8 1/2°, that is one turn in 24·13 calibres
Length of bore rifled 32"·659. The rifling thus
makes 0·53 turn in the bore.

Lithographed at the Royal Artillery Institution


1″555
0″26
1″037
0″518
2″333
2″691
1″555
6″37
1″555
0″52
a
1″408
3″11
0″518
3″11
10″368
17″626
6″231
5″433
1″555
1″555
1″037

MOUNTAIN ARTILLERY MATÉRIEL.

The gun, its nomenclature and object.

1. The *matériel* of the Austrian mountain artillery, pattern 1863, consists of 3-pr. rifled mountain guns, ammunition, lading gear, gun implements, mule equipment,* and other articles.

The denomination of the mountain rifled gun is derived, as with field guns, from the weight of the cast-iron round shot nearest approaching in diameter to the 3-pr. rifled projectile.

The 3-pr. rifled gun is exclusively intended for mountain warfare. In the construction of the piece, and in the organization of the whole *matériel*, two points have been held in view; that, while the effect of the projectiles shall be adequate to the exigencies of mountain warfare, the mules laden with guns and ammunition, shall be able to traverse mountains with facility.

The rifled mountain gun fires at low angles as a gun, and at high angles as a howitzer.

I. The gun.

The piece.

2. The outward form of the bronze gun (Fig. 1) consists of two truncated cones connected by a curved surface; the lesser truncated cone extends from the muzzle to a distance of 7″·2 in rear of the trunnions, the greater, from thence to the end of the breech.

The gun has the usual muzzle swell, copper vent bouche, cascable, and trunnions with shoulders. The axis of the trunnions is 0″·993 below the axis of the piece. The diameter of the vent is 0″·26, the bouche being set in at an angle of 7°.

The bore (Fig. 1) consists of the smooth-bored cylindrical powder chamber *a*, with an hemispherical end; and of the bore proper *b*, rifled with six grooves, each of which has the form of an eccentric arc. The form and disposition of the grooves is shewn in Fig. 2, which represents a section of the bore at the muzzle, as seen from the front of the piece. The dotted line is the generating circle of the cylinder, the full lines represent the grooves. The bottom *cd*, of each groove is a circular arc whose centre does not coincide with the centre of the generating circle of the cylinder forming the bore. The diameter of that cylinder is 2″·916, the maximum depth of groove is 0″·13, the width 1″·452, and the windage 0″·065.

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* The word in the original here translated "mule," is equivalent to "beast of burden," this rendering obtains throughout the following pages.

The grooves make 0·53 of a turn from left to right in the length of the bore rifled. The pitch angle is 8½°.*

In order to comprehend the principle upon which the grooving is constructed, it is necessary here to describe the exterior form of the projectile, and to show the position of the projectile in loading and firing.

The cylinder of the projectile is similar in section to the bore, having six wings or ridges exterior to the generating cylinder. Fig. 3 shews the outline of the projectile in section, the generating circle being shewn by the dotted line, and the outlines of the ridges by the full lines. The form of the ridges corresponds to that of the grooves, but the diameter of the generating circle of the projectile is 0″·065 less than that of the bore. Supposing the projectile entered into the bore in the act of loading (Fig. 4), the lower ridge *l* would lie at the bottom of the lower groove, whilst between all the other ridges and their corresponding grooves, there would be the windage shewn in the drawing; at the point *h* it amounts to 0″·065, the difference between the diameters of the bore and projectile. In this position the projectile is rammed home in loading up to the smooth-bored powder chamber; in going home it makes the amount of revolution determined by the twist of the grooves, and slides with the lowest ridge constantly in contact with the bottom of the corresponding groove, in virtue of its weight. As soon as the bottom of the projectile has reached the rear end of the rifled part of the bore, the projectile is twisted to the right by the rammer head which is specially adapted to this purpose, and thus is brought into the position shewn in Fig. 5; in this position the ridges of the projectile are in contact with the parts *lm* of the arcs of the grooves, whilst the windage is distributed in the manner shewn by Fig. 6.

In this centred position the projectile is driven forwards by the impulse of the powder gas, and is at the same time set in rotation from left to right by the twist of the grooves. The right sides of the grooves, as seen from the front of the gun, form the bearing surfaces for the ridges; they guide the projectile, and keep the long axis of the projectile, while in motion, in the axis of the piece.

This construction of grooving admits of sufficient windage for easy loading, while at the same time the projectile is supported in its centred position in firing; and as the bearing surfaces are proportionately large, the projectile has a much steadier motion on this system than on any other system in use with muzzle-loading guns.

The system of sighting (Fig. 7) is as follows:—

At the upper surface of the breech is a flat *p* with a short V shaped engraved line *i*; the former forms a footing for the base of the tangent scale in firing at short distances, the latter is used for line-of-metal sighting; on the rear surface of the base of the breech on the right-hand side is a groove, into which the base of the tangent scale fits in firing at long distances. On the shoulder of the right trunnion is a steel centre sight with V notch, attached by two screws; the sighting is taken over the centre sight when the tangent scale is entered into the afore-mentioned groove on the breech-base. The muzzle has a dispart patch with V notch. The line of sight with an elevation of 0° is parallel to the axis.

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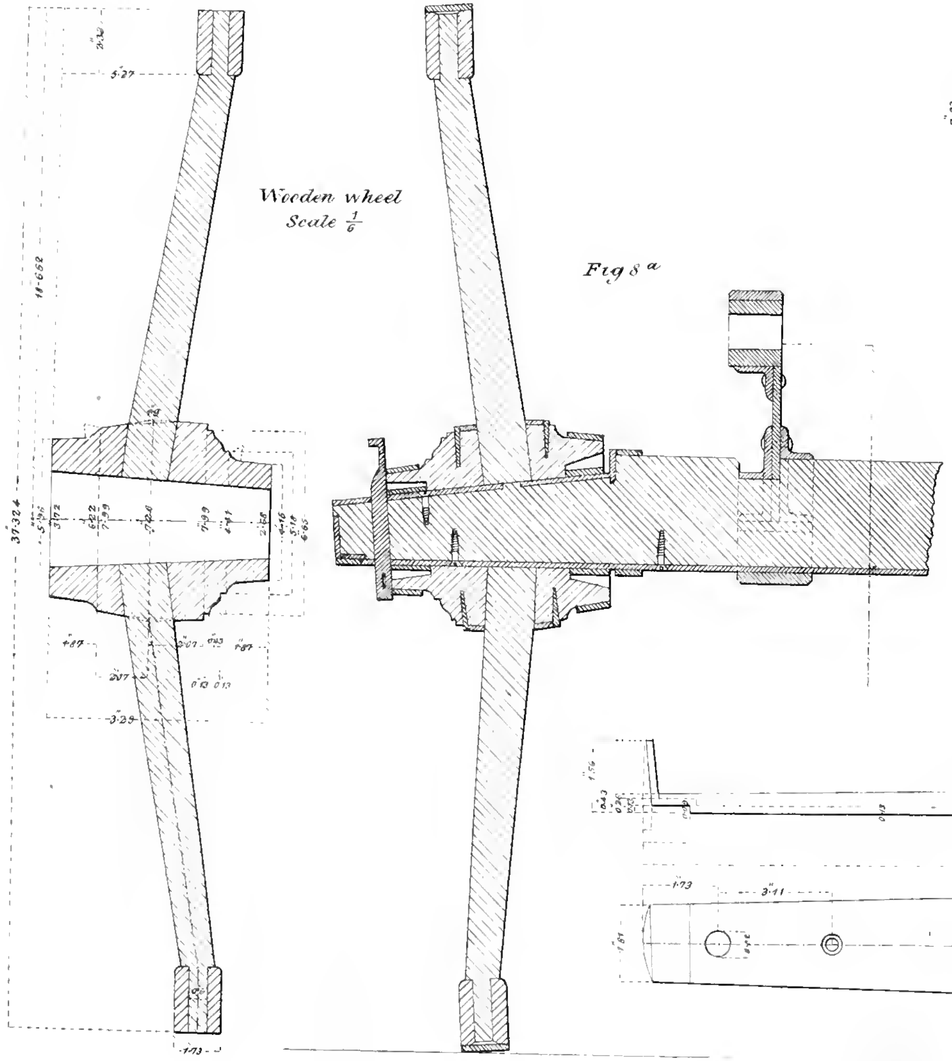
* One turn in 24·13 calibres.

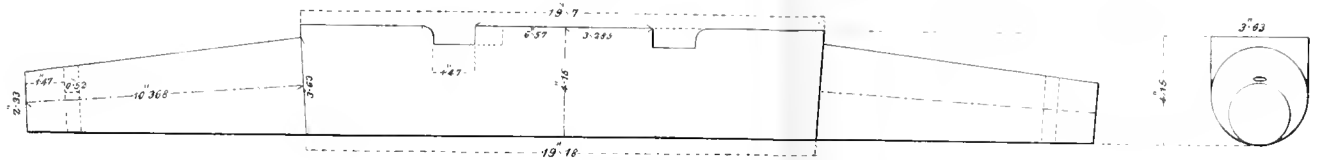
DETAILS OF 3 P^R M. GUN CARRIAGE.



Wooden wheel
Scale $\frac{1}{6}$

Fig 8^a

Fig 8^c
Wooden axle
Scale $\frac{1}{6}$



Linch-clout & Shoulder clout, Scale $\frac{1}{4}$

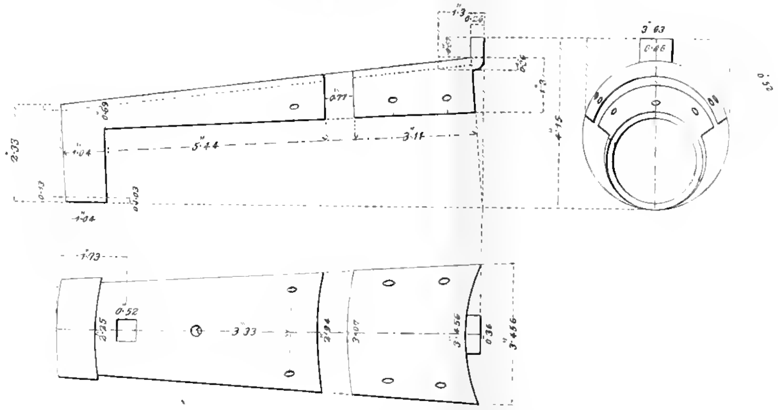
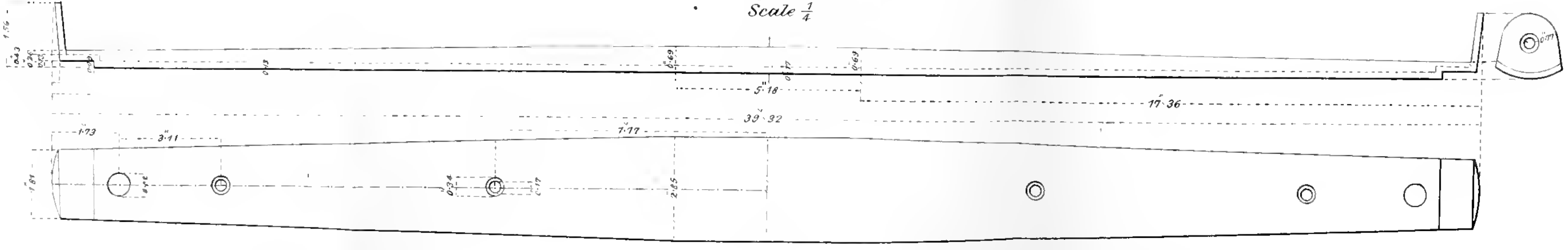


Fig 8^d
Axle garnish-plate
Scale $\frac{1}{4}$



Lithographed at the Royal Artillery Institution

The gun exclusive of the cascable is 37″·325 in length, inclusive, 40″·435; the length of bore rifled is 32″·659; the length of the smooth-bored powder chamber is 3″·11.

The 3-pr. gun weighs 191·4 lbs.; its breech preponderance is 46·9 lbs.

The carriage.

3. The carriage (Fig. 8, *a*, *b*, *c*, *d*, *e*) is of course constructed in proportion to the piece; it is composed of two plate-iron cheeks, a wooden axle,* two wooden wheels, and an elevating apparatus.

The cheeks, stiffened by riveted angle-iron, are connected together by a transom-bolt, elevating screw-bridge, and trail-shoe. Further, they are fitted with: two trunnion seats and capsquares, snugs and keys, two axle-bands, two recoil-rope hooks, two recoil-rope rings, two angle-iron keepers in rear of the elevating screw-bridge for keeping the carriage in its place on the saddle, and finally, a vent stopper attached by a chain to the right cheek of the carriage.

The wooden axle is 39″·914 in length; its body is plated with iron the whole length of its lower surface; on the body further are two linch-clouts † and two shoulder-clouts, and finally, on the arm two ferules and two linch-pins.

The wheels are 37″·325 in diameter; each has five felloes, ten spokes, a nave with an outer and inner axle-bush, two spoke rings and two nave rings.

The elevating apparatus consists of the bronze nut fastened to the elevating-screw bridge, and a wrought-iron elevating screw, with flanged head and horns. The apparatus gives an elevation of 25°, and a depression of 8°.

The weight of the gun-carriage with its wheels is 206·18 lbs. The width of track is 29″·03; the height of the gun, riding on its carriage above the ground is 26″·697; a straight line joining the middle point between the trunnion seats and the point of the trail where it rests on the ground, forms with the horizontal line of the ground an angle of 35°; the total length of the carriage, measured horizontally is 61″·43. The gun and carriage complete weighs 398·78 lbs. The mountain gun has no limber.

II. AMMUNITION, AMMUNITION-BOXES, STORES, AND MULE EQUIPMENT.

Ammunition.

4. The ammunition of the rifled mountain gun comprises low and high-angle, saluting and exercising cartridges, common and shrapnel shells, case shot, and the ordinary friction tubes.

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* The weight of iron is eight times that of oak; the strength of iron is only four times that of oak (for the same size): hence weight for weight and for similar sections oak is *twice* the strength of wrought-iron. Thus, an axle of iron weighing 60 lbs. might be replaced by one of oak weighing 30 lbs., with an addition of weight for plates. The stiffness of iron and the facility which it offers of placing the metal where the strain is greatest, as in the girder form, are the points in its favour which renders it generally preferable. (Note communicated by Mr Butter, R.C.D.)

† *Clout*, a patch. "Old shoes and clouted."—Josh. ix. 5.

(*a*) *Common shells.*

The common shell (Figs. 9, 10) consists of the cast-iron shell, the coating, the fuze, and the bursting charge.

The cast-iron shell (Figs. 11, 12) is cylindro-ogival in form, on its nose are two drifts *w*, used in setting home and extracting the shell; internally is the screwed fuze hole *m*, which takes the fuze, and the cavity *h* for the bursting charge. On the cylinder of the shell are six grooves lengthwise, and three circumferentially for attaching the coating.

The coating (Fig. 9, 10, *l*) is composed of an alloy of tin and zinc poured when melted over the cast-iron shell; the latter by this process is furnished with six ridges, corresponding to the section of the bore (Fig. 9, *l*). These ridges extend from the base to the origin of the ogival nose of the cast-iron of the shell; they have the same pitch as the grooves of the piece. The diameter of the generating circle of the projectile is 2″·851, the projection of the ridges 0″·13, and their width 0″·389.

The fuze is a "concussion fuze," it contains no percussion powder, and is so contrived as to explode the shell on its grazing or striking any solid object. The component parts of the fuze (Fig. 13) are: the iron fuze-hole screw-plug *m*, and the brass case *n*; the latter, in the upper part, contains a hollow cylinder *c* of a compressed composition of mealed powder and charcoal; in the lower part, a small magazine of musketry powder, separated from the composition cylinder by a brass button *r*. The bottom of the case is closed with thin sheet brass.

The fuze hole plug has a hollow neck, with holes in it communicating with the composition cylinder; a strand of quickmatch is wound round the neck, and the ends passed through the holes. The quickmatch about the neck is protected by tin-foil.

The bursting charge of the shell weighs 4·94 oz.; the weight of the shell filled is 6·289 lbs.

When the gun is fired, the quickmatch round the fuze-hole plug takes fire from the flame of the charge and consequently ignites the composition cylinder. At the instant the shell grazes, the brass button is loosened in its seat and falls forwards followed by the powder in the magazine; the latter comes in contact with the red-hot composition cylinder and communicates its flame to the bursting charge.*

(*b*) *Shrapnel shells.*

The shrapnel shell (Fig. 14) is similar in exterior form to the common shell, but somewhat shorter; it differs from it, however, in the construction of the cast-iron shell, the fuze and bursting charge.

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* The same author in another work entitled "Essay on Artillery Tactics in reference to Infantry armed with breech-loaders," Vienna, 1868, states as regards the Austrian fuzes, "The fuzes of the present construction used with rifled guns, have reached a high state of perfection, as compared with those of previous construction; this may more especially be asserted with regard to the Austrian common and shrapnel fuzes. Nevertheless, the experience gained in the campaigns of the past year, indicates that the Austrian fuzes of both species are susceptible of improvement; this statement does not refer to the principle of construction, but merely that it is desirable that the action of the fuzes should be made more trustworthy and regular."

Captain Hozier, writing of the campaign alluded to, says, "The Austrian shells burst truly."

Fig 2.

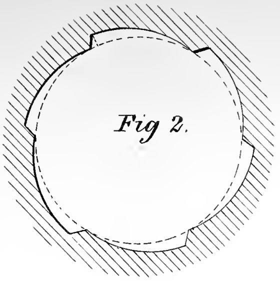


Fig 3.

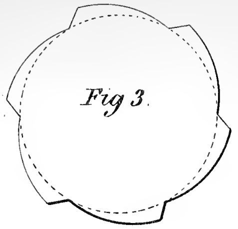


Fig 4.

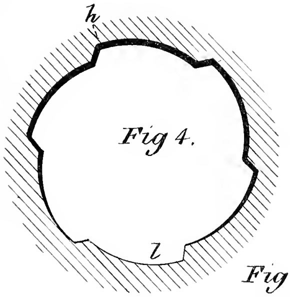


Fig 6.

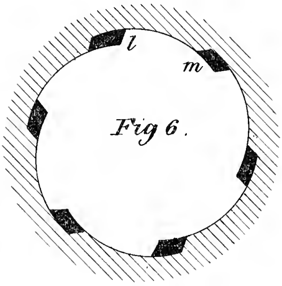


Fig 9.

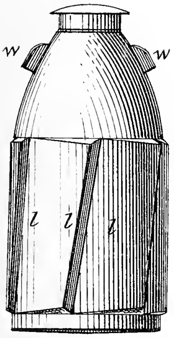
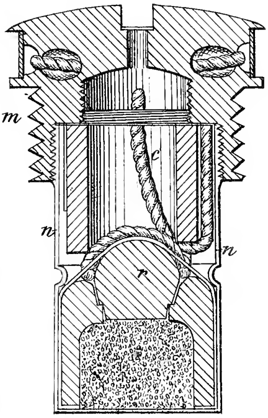


Fig 13.



Scale $\frac{1}{1}$

Fig 10.

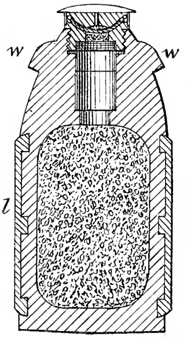


Fig 11.

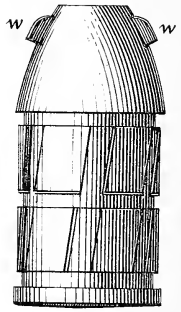


Fig 12.

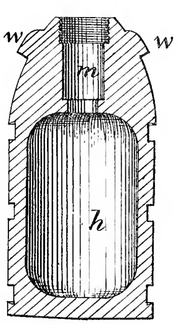


Fig 14.

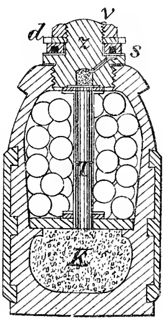
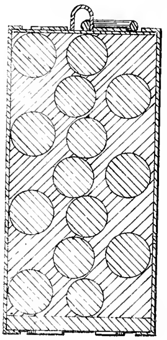


Fig 15.



Lithographed at the Royal Artillery Institution

The cast-iron shell in addition to the fuze-hole has a loading hole in the ogival part; further, the cavity of the shell is divided into two parts by a wrought-iron diaphragm with a central hole through it.

The charge of the shrapnel shell is composed of the burster, 1·54 oz. of musketry powder, contained in the cavity *K*; further, of 55 leaden balls, 26½ to the 1 lb., in the cavity above the diaphragm; melted sulphur is poured between the interstices of the bullets. The brass tube *T*, filled with powder communicates between the fuze and the bursting charge.

The loading hole, through which the leaden balls and sulphur are introduced into the shell, is closed by a screw-plug after the shell is filled.

The shrapnel fuze is Breithaupt's, with several important modifications; its component parts are, the body of the fuze (Fig. 14, *z*) the plate *s*, with its composition ring, the cover *d*, and the vent *v*.

At the bottom of the body of the fuze is a magazine filled with musketry powder; the magazine communicates with the above-mentioned composition ring by a vent filled with a quickmatch leader; the bottom of the magazine is closed with sheet brass.

On the outer surface of the plate, into which the composition is compressed, is a scale of ranges between 330 and 1244 yards; the composition ring is primed with quickmatch, both being protected by tin-foil; on the upper surface of the plate are two studs fitting corresponding recesses in the cover. The vent *v* screws down the cover and composition plate to the body of the fuze; a spanner is used for slackening the nut, when adjusting the fuze. The cover further has two studs with holes in them, into these the forked ends of the spanner fit to turn the cover and plate. The fuze is marked "3-pr." on the outside of the composition plate.

The fuze screwed into the shell is capped with a paper and a linen cover over the former, the latter being steeped in pitch. Both are tied round with twine.

The weight of the shrapnel shell filled and fuzed is 6·635 lbs.

(*c*) *Case shot.*

The case shot (Fig. 15) is a cylindrical sheet zinc cylinder with zinc cover and driving bottom plate; it is filled with thirty-four zinc balls, eleven to the 1 lb., and with melted sulphur to fill up the interstices. On the cover is a ring for facility in handling the shot. The case shot filled, weighs 5·015 lbs.

(*d*) *Lubrication of projectiles and canvas bags.*

The cylinders of the common and shrapnel shells and of the case shot are covered with a thin layer of a lubricant composed of melted tallow and olive oil; the object of this lubrication is to diminish the friction between the projectiles and the sides of the bore of the gun in loading, but chiefly to keep the residuum of the powder in a soft state to prevent excessive fouling in the bore.

To protect all projectiles from injury, and at the same time to preserve the layer of lubricant, each projectile is put into a canvas bag closed with the same material.

(*e*) *Cartridges.*

The low-angle cartridge is intended for firing with a flat trajectory; it is a bag of woollen stuff, and contains 7·4 oz. of ordnance powder.

The high-angle cartridge is used in firing with a highly curved trajectory; the bag is like the former in material, but contains only 3·9 oz. of ordnance powder.

The exercising and saluting cartridges are used as prescribed by their denominations.

All cartridges are marked in oil colour, with indication of their calibre and nature.

Ammunition boxes and packing.

5. The boxes for packing the 3-pr. ammunition (Fig. 16) are strengthened with iron clamps; internally the space is divided into three compartments by wooden partitions. The method of packing varies. The compartments *a* and *c* contain either 4 common shells each, and the central compartment *b*, 8 low and 4 high-angle cartridges and 1 bundle of friction tubes; or in *a* and *c*, 4 shrapnel shells each, and in *b*, 8 low-angle cartridges and 1 bundle of friction tubes; or lastly, the compartments *a* and *c*, each contain 4 case shot, and the compartment *b*, 8 low-angle cartridges and 1 bundle of friction tubes.

The projectiles encased in their canvas bags are packed base downwards; the cartridges in two layers, the length of the cartridge in the direction of the length of the box.

The 3-pr. ammunition box filled with common shell weighs 76·5 lbs.; with shrapnel shell, 77·8 lbs.; and with case shot 65·4 lbs.

Special packing bags and ordinary cartouches are used for packing baggage, spare *matériel*, and rations.

Gun implements and other articles of equipment.

6. The 3-pr. gun implements and articles of equipment are as follows:—

Tompion and vent cover both with buckling straps, sponge with rammer, drill sponge, handspike, fuze spanner with sling, binocular glass, specially intended for officers' use, priming iron and vent bit, tangent scale and vent bit case, tube pocket, cartouche, vent drift and hammer, canvas bag hooks, clasp knife with sling, kneecap, recoil rope, friction tube lanyard; finally pickaxe and shovel, lashing line, mule picket, cooking utensil, and drink keg.

Of the above-named articles, only those whose construction are least known will be described.

The tangent scale (Fig. 17) is of brass, and is constructed so as to give at the same time the elevation and the allowance for permanent deflection or *derivation* to the right, consequent on the rotation of the projectile. The tangent scale consists of the base *p*, with its lug *o*, the upright bar *s*, and the slider *u* movable up and down the bar; the cross-bar *q*, with an upper and lower V notch, traversing at right angles to the upright bar in a slot in the slider.

Fro

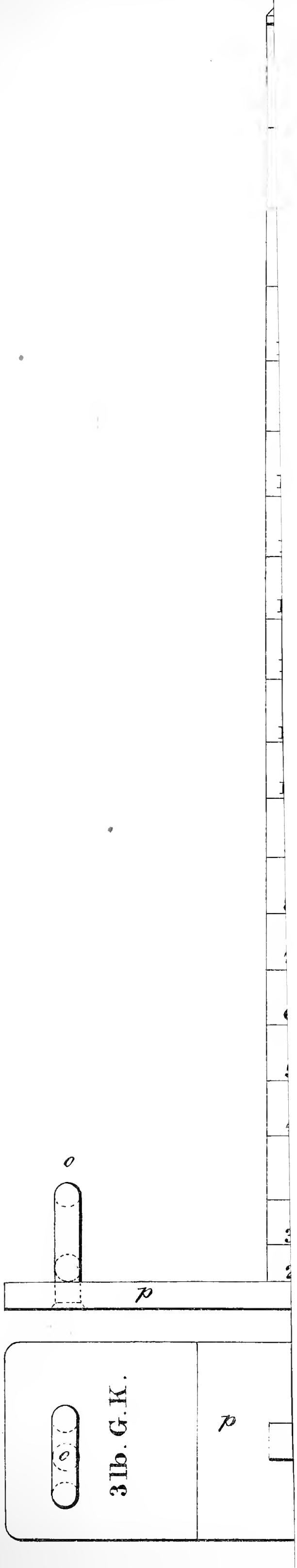
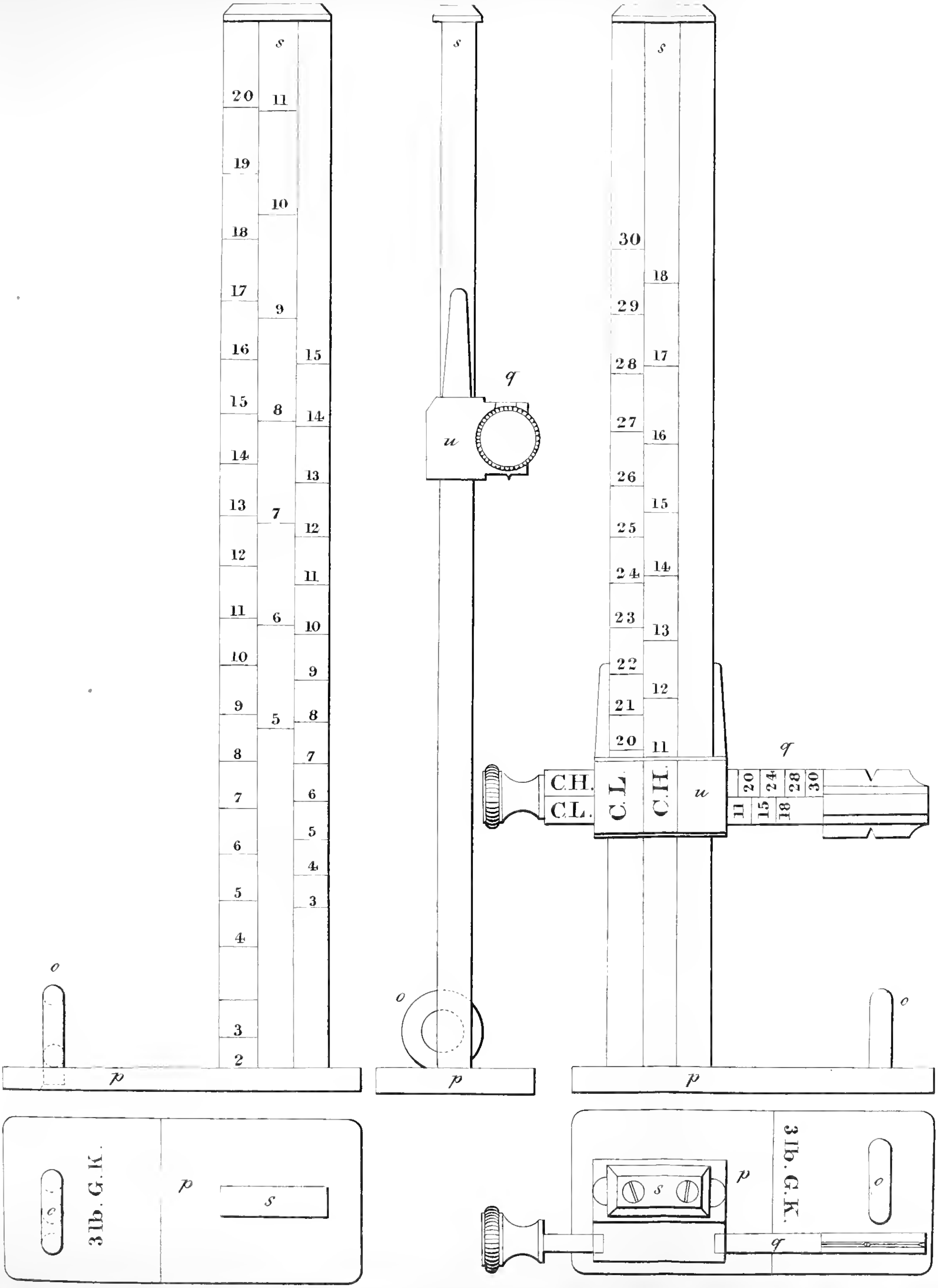


Fig 17.

Front Elevation Side Elevation Rear Elevation

Scale $\frac{1}{1}$



Lithographed at the Royal Artillery Institution

The upright bar is divided off into various lengths, giving the heights of scale for low and high angle fire of the different projectiles; similarly, the amount of allowance for deflection is given by the divisions on the traversing bar. In both cases, above the divisions on the upright and traversing bars, the number of hundreds of yards is stamped, shewing the ranges to which the vertical and horizontal lengths are applicable.

Upon the front[*] of the upright or tangent-bar is a scale marked C.L., used in firing common shells at low angles at ranges from 170 to 1700 yards; a second marked C.H. used in firing the same projectile at high angles between 400 and 900 yards; and a third marked S.L., used in firing shrapnel shells at low angles from 250 to 1250 yards.

On the rear side of the scale is a continuation[†] of the scale used in firing common shell at low angles from 1700 to 2500 yards, and further the continuation of the scale for firing the same projectile at high angles from 900 to 1500 yards. All the letters above-mentioned are engraved on the slider in prolongation of the scales they refer to.

On the front side of the traversing bar is a *derivation* scale marked C.L., used in firing common and shrapnel shells at low angles, and a second scale marked C.H., used in firing the former projectile at high angles.

On the back of the traversing bar is the continuation of both these scales.

The divisions on the *derivation* scales used in firing common and shrapnel shells at low angles are given for every 400 yards, those used in firing common shell at high angles for every 200 yards.

The base of the 3-pr. tangent scale is marked "3-pr. M.G."

The tangent scale is carried in a leather case, slung over the right shoulder of the pointsman, by a lanyard passing through the lug at the base of the tangent scale; the lanyard is sufficiently long to allow of the tangent scale being used without unslinging it. On the march, the tangent scale is carried in the right-hand cartouche of the gun-mule.

The tangent scale and vent bit are kept in one leather case which has two sheaves appropriate thereto, and a body strap for buckling it to the pointsman.

The service sponge (Fig. 5) consists of a staff, the sponge head, strap staple, and the rammer head *l* of stout sheet-iron; the last is used in ramming home the cartridge and projectile and in extracting common and shrapnel shells; for this purpose the circumference is cut out in two places *a*;[‡] these cuts fit and grip the two drifts on the nose of the projectile.

The sponge when not in use is strapped to the cheek of the carriage.

The drill-sponge is the same as the above, with the exception that it has an ordinary wooden rammer-head in lieu of one of sheet-iron.

The fuze spanner (Fig. 18) has a pair of jaws to take the nut of the fuze, the points of the jaws form two studs.

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[*] When the lug on the base of the tangent scale is to the left of the upright bar, the side of the scale next the eye is the "front side."

[†] The divisions are calculated with the shorter radius from breech to trunnion sight.

[‡] Like the bayonet joint.

The cartouche is divided into two compartments and has a leathern sling to hang on the gunner's shoulder.

The knee-cap is used to protect the right knee of the pointsman, as he has to kneel on his right knee to lay the gun, in consequence of its being so low off the ground.

The recoil-ropes are used for checking the recoil; they are 57″ long, and are fitted with hooks and rings.

The handspike is used in lading and unlading the gun off the pack-saddle; it is 31″·1 long, and in travelling is carried in the bore of the gun.

Among other articles of equipment of the mountain battery is a portable forge, represented in Fig. 19. It consists of an iron hearth-plate and fire-box *h*, four iron feet *f*, cylindrical bellows *b*, iron blastpipe *r*, two connecting rods *z*, and blast lever *d*. To load the bellows a stone of from 5 to 7 lbs. in weight may be used.

The mountain forge weighs 79 lbs. and the iron anvil appertaining to it, 72 lbs.

For transport the forge is taken to pieces, the pieces being packed in special bags for lading. In taking the forge to pieces, the blast lever and connecting rods are first unshipped, then the blastpipe is unscrewed, the bellows and bellows support are removed, and finally the four legs are taken out of the clamps on the fire-box.

The forge is put together in the reverse order.

Mule equipment.

7. As already mentioned, the guns, carriages, and ammunition-boxes of the mountain guns, as well as the men's kits, forage, field stores, and other necessaries, are carried on mules equipped for that purpose with pack-saddles and other gear.

The pack-saddle is fitted differently, according as it is intended for gun, gun-carriage, ammunition or baggage and other matters.

The gun pack-saddle (Fig. 20) is composed of: an iron bound saddle-tree (consisting of 2 arches, 2 side-bars, 2 trunnion cheeks and transom forming the cradle), 2 cross-girths or luggage straps, 2 hair girths with 2 saddle straps each, 2 breeching and 2 breast collar buckling straps, 2 gun straps, and 2 gun straps with buckle ends.

The gun-carriage pack-saddle (Fig. 21) differs from the above in so far that the saddle-tree has no cradle, and instead of the 2 gun straps, and 2 gun straps with buckle ends, it has four belaying straps.

The ammunition and baggage pack-saddle (Fig. 22) consists of an iron-mounted saddle-tree (2 arches and 2 side-bars) 2 cross girths, 2 girths each with 2 girth straps, 2 side-chafing pieces, 2 breeching and 2 breast collar buckling pieces, and 4 suspending hooks.

The saddles are made of three sizes (large, medium, and small).

The equipment of each mule consists of 1 black horsecloth, 1 pack-saddle pad, one 4″ saddle girth, 1 cavalry bridoon, 1 head-stall and halter, 2 leading reins, 1 breast-collar (consisting of 1 sweat piece or neck strap, 2 straps, 2 shoulder straps, and 1 rosette), 1 breeching (consisting of 1 sweat piece or breech strap, 2 straps, 2 hip straps and 1 loop); in addition to the above the gun-carriage pack-saddle has, 1 wanty, 1 wheel bearer, 1 trail-pad; the ammunition pack-saddle has, 1 wanty, 4 suspending hooks and 1 canvas pack-cover; finally, for the baggage pack-saddle must be further added, packing-girths and packing splints, as may be required, 1 canvas pack-cover, 4 packing girths with ties, and 4 triangular pack-rings, each with a four-link chain.

The dimensions and materials necessary for making the components of mule equipment, are contained in the following table:—

Table

GIVING THE DIMENSIONS OF THE CHIEF COMPONENTS OF MULE EQUIPMENT, AND THE MATERIALS NECESSARY FOR MANUFACTURE.

Parts.	Long.	Broad.	Materials requisite.
Canvas pack covers.	in.	in.	
Pack-covers complete	106	55	0·014 black horse hide.
Lashing lines to each { two long	124	—	6·18 yds. 0·85 broad water-proof canvas.
two short	87	—	0·3 oz. unbleached sewing twine.
Two round rosettes	3	—	0·6 oz. ordinary sewing thread.
26 loops, each	4	1	13 yds. lashing line.
			0·15 oz. black pitch.
			0·07 oz. yellow wax.
Black horse-cloths.			
Blanket	75	62	Weight from 7·4 to 8·6 lbs.
Pack girths.			
Pack-girths, with rings sewn on...	62	3	2 half-round rings.
" lines 0″·3 thick	75	—	0·04 oz. unbleached sewing twine.
			0·1 oz. ordinary sewing thread.
			1·86 yds. 3″ hair girthing.
			1 piece pack-line, 2 yds. long.
			0·04 oz. of yellow wax.
Wanty, or swing girth.			
Girth	31	3	2 buckles, No. 2. without rollers.
2 straps	31	1	0·030, 2nd class alum-hide.
Buckle piece	31	1	0·3 oz. ordinary sewing thread.
4 keepers	—	$0\frac{3}{4}$	0·87 yd. 6″ hair girthing.
			1·2 oz. logwood.
			0·3 oz. leather lacquer.
			0·07 oz. black pitch.
			0·3 pint iron lacquer.
			0·3 oz. melted tallow.
Saddle under girth.			
Girth	44	4	4 buckles, No. 4, with rollers.
Split of the girth at each end	13	—	$\frac{1}{60}$ 2nd class alum-hide.
4 buckle covers	$4\frac{1}{2}$	$4\frac{1}{2}$	0·6 oz. ordinary sewing thread.
2 cross pieces } of the breadth of {	4	$2\frac{1}{4}$	1 piece of girthing uncut.
4 keepers ... } the girth ...... {	$2\frac{1}{4}$	$0\frac{3}{4}$	0·6 oz. leather lacquer.
Cross-keepers (in the middle of the length of the girth sewn on, of the breadth of the girth)	5	$1\frac{1}{2}$	0·2 oz. black pitch.
			0·2 pint wheel grease.
			0·07 pint melted tallow.
Stable halter and head stall.			
Head strap	32	$1\frac{1}{4}$	For head stall.
Nose band	13	$1\frac{1}{4}$	1 belt ring.
2 throat pieces	6	$1\frac{1}{4}$	2 small halter rings.
Ring piece	5	$1\frac{1}{6}$	1 No. 2 buckles without rollers.
Cheek piece	$7\frac{3}{4}$	$1\frac{1}{4}$	1 No. 3 " "
Throat strap	19	1	$\frac{1}{16}$ 1st class alum-hide.
" buckle strap	10	1	1 oz. No. 10 sewing thread.

Parts.	Long.	Broad.	Materials requisite.
Stable halter, &c. continued.	in.	in.	
Browband	16	1	0·6 oz. logwood.
2 keepers and 1 slider	4	0¾	0·2 oz. black pitch.
Halter rope, $\frac{4}{10}$″ thick	75	—	0·3 oz. melted tallow.
Sheathing near buckle	7	2	For halter.
Strap	9	1	$\frac{1}{200}$ 1st class tanned hide.
Buckle-keeper	3	0¾	1 No. 2 buckle without roller.
Cavalry bridoon			0·3 oz. sewing thread.
			1 piece rope uncut.
			0·3 oz. leather lacquer.
			0·04 oz. brown pitch.
			0·04 oz. lamp black.
			0·04 oz. cart grease.
Pack-saddle panel.			
2 parts of the panel	28	23	1 No. 2 buckle without roller.
2 panel linings of canvas	28	23	4 No. 3 " with "
Panel canvas	33	30	0·040 3rd class alum-hide.*
Divided upper part	11	0	0·4 black horse-hide.†
" lower " front	8	—	3·4 yd. and 0·85 broad tent canvas.
" " " rear	11	—	0·3 oz. unbleached sewing twine.
Hollow part	20	7	0·6 oz. strong pack-thread.
" " in the middle	—	5	0·6 oz. sewing thread.
Front hollow border	2	1¾	0·6 oz. logwood.
Hind " "	—	1¼	11 lbs. cowhair.
4 binding straps for attaching buckle pieces	14	0¼	7·4 lbs. glue. 0·3 lbs. black pitch.
2 binding straps	50	0¼	1·2 lbs. melted tallow.
2 buckle-pieces (from buckle to buckle)	22	1¼	0·15 lbs. yellow wax.
Keepers	3	0¾	
" housing	9½	1¼	
Opening at the buckle-piece	6	—	
Buckle-girth	19	1	
Keepers	3	0¾	
2 bearing-straps	100	1	
The buckle-pieces distant from below, in front	2½	—	
" in rear	3	—	
Trail pad.			
Top	14	9	0·01 1st class tanned hide.‡
Bottom	14	9	0·15 3rd " "
Side	48	4½	0·6 oz. ordinary sewing thread.
The side pieces, front and rear, are curved out at their lower edges...	—	1	3·1 lbs. cow hair. 0·15 pint iron lacquer.
2 straps	15	1	0·04 oz. yellow wax.
2 loops on the bottom	3	0¾	
Top and side binding	48	0½	
Bottom and side binding	48	1	
The 2 loops are sewn on from front to inside end	—	0¾	
" rear "	—	0¾	
" front to side	—	3¼	
" rear "	—	0¾	
3-pr. gun pack-saddle.			
2 arches (ash)	—	—	1 set iron mountings, gun pack-saddle.
2 side bars (lime tree)	—	—	80 ordinary nails.
2 trunnion cradle walls and transom (ash)	—	—	2 No. 4 black buckles. 4 No. 3 " with rollers.
2 cross girths	25	3	0·078 3rd class alum-hide.§
2 girths	30	3	0·028 1st " tanned " ‖
4 saddle straps	19	1½	8 wood screws, half-round heads.
Saddle strap strengthening pieces	19	1	1·2 oz. ordinary sewing thread.

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* For binding straps, buckle pieces, girth buckles, and sliders.

† For the borders of the hollow part and the bearing straps.

‡ For the two straps.

§ For the saddle straps and front and rear buckle pieces.

‖ For cradle and transom buckle and strap pieces for the centre chapes of the girths.

Parts.	Long. in.	Broad. in.	Materials requisite.	
Straps on the cradle walls	10	1½	3·1 yds. 3″ broad hair girthing.	
" transom	14	1½	1·2 oz. logwood.	
Buckle pieces on the cradle walls...	5	1½	0·3 oz. black pitch.	
" " transom	9	1½	1·2 oz. melted tallow.	
Front and rear buckle pieces	3	1¼		
" sliders for the same	—	0¾		
4 leather chapes for the cross girths	2½	3		
2 do for the strapping	6	1¼		
3-pr. gun-carriage pack-saddle.				
2 arches (ash)	—	—	1 set iron mountings for gun carriage pack-saddle.	
2 side bars (lime tree)	—	—		
2 cross girths, each	25	3	80 ordinary nails.	
2 straps	31	3	4 black buckles.	
4 saddle straps..........................	19	1½	4 No. 3 " with rollers.	
" strengthening pieces	19	1½	0·078 3rd class alum-hide.*	
4 gun-carriage buckling straps......	31	1½	0·070 1st " tanned "	
Front and rear buckle pieces	3	1¼	1·2 oz. ordinary sewing twine.	
" sliders for the same	3	0¾	3·1 yds. 3″ broad hair girthing.	
4 leather chapes for the cross girths	2½	3	1·2 oz. logwood.	
2 do for the strapping girths	6	1¼	0·3 oz. black pitch.	
			1·2 oz. melted tallow.	
Ammunition and baggage pack-saddle.				
2 arches (ash)	—	—	1 set iron mountings for ammunition and baggage pack-saddle.	
2 side bars (lime tree)	—	—		
4 suspending hooks			10 ordinary nails.	
2 cross girths	25	3	4 No. 3 buckles with rollers.	
2 strapping do..........................	31	3	0·078 3rd class alum-hide.	
4 saddle straps..........................	19	1½	0·090 2nd " brown cow hide.†	
" strengthening pieces	19	1	1·2 oz. ordinary sewing thread.	
2 side pieces (trapeziums) measuring .... {below	8	9	3·1 yds. 3″ broad hair girthing.	
{above	19	9	1·2 oz. logwood.	
Front and rear buckle pieces	3	1¼	0·3 oz. black pitch.	
" sliders for the same	3	0¾	1·2 oz. melted tallow.	
Leather chapes for cross girths ...	2½	3		
" for the strapping girths ...	1¼	3		
Wooden packing splints.				
Splints	—	—	8 flat-headed wood screws.	
2 sliders thereon	6	1¼	0·04 3rd class alum-hide.	
" strengthening pieces	1¼	0¾	0·14 oz. logwood.	
			0·14 oz. melted tallow.	
Triangular pack-ring with 4-link chain.			0·002 2nd class brown cow hide.	
Leather housing	5	1	0·05 oz. ordinary sewing thread.	
			0·01 oz. yellow wax.	
Breeching.			Breeching.	Breast collar.
Sweat-piece or breeching	34	2¾		
2 straps	22	1¼		
2 hip straps	44	1¼		
Runners	2½	2¼		
Breast collar.			0·100	0·095 2nd class alum-hide.
Neck strap	31	2¾	0·3	0·3 oz. sewing thread.
2 straps	22	1¼	0·6	0·6 oz. logwood.
2 bearing straps	37	1¼	0·2	0·2 oz. black pitch.
Rosette....................................	—	1⅙	0·6	0·6 oz. melted tallow.
			1 No. 2 buckle without rollers.	
Leading reins.			0·024 2nd class alum-hide.	
Leading reins	50	1	0·15 oz. ordinary sewing thread.	
Straps	10	1	0·3 oz. logwood.	
Buckle keepers	3	0¾	0·04 oz. black pitch.	
			0·15 oz. melted tallow.	

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* As with gun pack-saddle.

† For the side pieces and leather chapes.

III. COMPOSITION, ESTABLISHMENT, AND EQUIPMENT OF MOUNTAIN BATTERIES, AND LADING OF MULES.

The composition of mountain batteries.

8. For tactical and administrative reasons, the rifled guns of a mountain battery with their ammunition and other *matériel,* the mules for transport, the men for serving the guns and for the care and guidance of the mules, and finally the officers and non-commissioned officers for supervision and command, are reunited into batteries, termed 3-pr. rifle mountain batteries.

As the nature of the country and style of combat consequent on it, generally speaking, are such as only to admit of a small number of guns being engaged in a single action, the mountain batteries consist of four 3-pr. rifled mountain guns only.

Establishment of a mountain battery.

9. Strength of a mountain battery on the war and peace footing:—

War.	Peace.	
		Personnel.
1	1	Captain, 1st or 2nd.
	1	1st Lieutenant.
1	2	2nd 〃
3	3	Fireworkers.
2	4	Serjeants.
5	6	Corporals.
1	1	Trumpeter.
8	16	Bombardiers.
31	22	1st class gunners.
46	32	2nd 〃 〃
2	4	Officers' servants.
1	—	Farrier.
		Personnel—continued.
1	1	Smith.
1	1	Saddler.
103	94	
		Horses and Mules.
4	4	Mountain saddle horses.
46	8	Mules.
2	1	〃 spare.
52	13	
		Carriages, gun and draft.
4	4	3-pr. guns.
2	2	2-horse country carts.

The following table gives the stores of a 3-pr. mountain battery:—

List of stores of a 3-pr. mountain battery on the peace (P) *and on the war* (W) *footing.*

Gun.	P.	W.	Nature of Stores.
			Guns and fittings.
1	4	4	Guns, 3-pr., pattern 1863, rifled, bronze, mountain.
			Gun carriages.
1	4	5	Carriages, gun, plate-iron, mountain, complete.
			Gun equipment stores.
1	4	5	Scales, tangent, brass, pattern 1863, rifled mountain gun.
1	4	5	Handspikes, 31·1″ long.
—	4	2	Glasses, binocular, with case and strap.*
1	4	4	Drifts, gun, vent.

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* The binocular glasses are in charge of the battery commander, and are given out to the officers for use on service.

Gun.	P.	W.	Nature of Stores.
1	4	4	Cases, leather, tangent scale and priming iron.
1	4	6	Spanners, time fuze
—	1	2	Hooks with haft, canvas bag.
1	4	4	Hammers, with handle, for clearing vent.
1	4	4	Levers, iron-mounted, with strap for lading.
1	4	4	Tompions, 3-pr. rifled mountain gun, with straps
1	4	5	Kneecaps.
2	4	8	Sponges, with rammer heads, 3-pr. service.
—	4	—	〃 drill.
1	4	4	Knives, clasp.
1	4	4	Irons, priming, service.
—	4	—	〃 〃 drill.
2	8	8	Bits, gun, vent.
2	8	8	Lanyards, friction tube, with hooks and toggles.
—	16	8	Lanyards, tangent scale.
2	8	10	〃 ordinary.
3	12	14	Ropes, recoil, 3-pr.
1	4	4	Pockets, tube and fuze-spanner, with straps.
—	—	1	Cartouches, cartridge, common.
3	12	12	〃 in three compartments.
			Draft carriages.
—	—	2	Wagons, 2-horse, country.
			Harness.
—	9	48	Horsecloths, black.
—	9	45	Bits, bridoon.
—	—	2	Harness, draft, 2-horse, sets.
—	9	5	Girths, surcingle.
—	16	22	〃 pack, with ties.
—	4	28	〃 swing or wanties.
—	—	4	〃 saddle, with holes punched
—	—	4	Hooks, suspending, with screw-nut and key.
—	9	50	Halters, stall, without chains.
—	32	124	Chains, suspending, with hooks.
—	9	50	〃 halter, stall.
—	16	14	Rings, triangular, with 4-link chains.
7	8	33	Saddles, pack, ammunition and baggage, complete.
1	4	6	Saddles, gun-carriage.
1	4	5	〃 gun.
—	16	8	Splints, packing, with sliders and lanyards.
—	10	53	Ropes, halter.*
—	19	90	Reins, leading, plain.
			Stable gear.
—	3	2	Buckets, water, iron bound.
—	—	7	Pails, canvas.
—	2	5	Hobbles, foot, hempen.
—	13	39	Combs, curry, with hand-straps.
—	13	52	Pickets, iron-shod, horse, small.
—	4	34	Sacks, corn, 1 peck.
—	8	16	〃 〃 2 〃
—	13	37	Combs, mane, with hand-straps.
—	26	78	Bags, forage.

Gun.	P.	W.	Nature of Stores.
			Entrenching tools.
—	4	8	Axes, pick, with helves.
—	4	8	Shovels, digging, light.
			Service ammunition.†
140	160	560	Tubes, friction.
72	64	228	Shells, common, 3-pr., filled and fuzed.
24	32	96	〃 shrapnel, do
16	33	64	Shot, case, 3-pr.
112	128	448	Cartridges, filled, 3-pr., low angle
36	32	144	〃 〃 〃 high 〃
			Drill ammunition.
—	1	—	Shells, common, 3-pr., filled with clay and fuzed.
—	1	—	〃 shrapnel, 3-pr., without powder and fuzed.
—	1	—	Plugs, in lieu of concussion fuze.
—	2	—	Fuzes, shrapnel, not loaded.
—	1	—	Cartridges, 3-pr., filled with sand, high angle.
—	1	—	〃 low angle.
			Packing necessaries.
—	—	1	Can, tin, grease.
—	—	1	〃 〃 harness-blacking.
112	131	448	Bags, canvas, with covers, projectile.
—	2	12	〃 packing.
—	—	1	Case, leather, packing, for mountain forge.
—	—	1	〃 for vice and fittings.
—	—	1	〃 for anvil and water bucket.
—	—	1	〃 for smithy tools.
—	—	1	Cartouche, leather, with leathern loop.
—	1	—	Chest, iron-clamped, for battery tools.
14	16	56	Boxes, ammunition, 3-pr.
—	1	—	〃 iron-clamped, ammunition, small-arm.
			Metals.
—	4	10	Tongues, buckles, No. 1.
—	4	10	〃 〃 〃 2.
—	4	10	〃 〃 〃 3.
—	20	78	Shoes, iron, mules.
—	400	1700	Nails, iron, mule shoe.
—	100	200	〃 ordinary.
—	2	5	Rings, girth, tinned.
—	4	10	〃 large, half-round, tinned.
—	4	10	〃 halter.
—	4	10	Buckles, tinned, without rollers, No. 2.
—	4	10	〃 No. 3.
—	4	10	〃 with rollers, No. 3.
—	4	10	〃 〃 No. 4.
—	0¼	0¼	Steel, 1 lb., for repair of tools.
			Leather.
	0¼	0½	Hides, tanned, black, alum.
	0¼	0¼	〃 〃 〃 plain.

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* The rope-halters are to be used in batteries, until the whole stock in the district store is expended; the stall-chains lately introduced will then be substituted.

† The peace-footing ammunition may, under the orders of the general in command of the district, be deposited in the nearest ordnance depot, in which case the battery retains 16 empty ammunition boxes.

Gun.	P.	W.	Nature of Stores.
			Yarn and cloth.
—	2	2½	Rags, cleaning, lbs.
—	—	1¼	Cloth, hemp, yds.
—	1	3·4	Canvas, tent, 0·85 yd. broad, yds.
—	0⅛	0⅛	Thread, sewing, unbleached.
			Rope-ware.
—	0¼	0½	Twine, sewing, No. 12, lbs.
—	—	4	Girthing, hair, 3″, yds.
—	—	83	Line, lashing, 0·17″ thick, yds.
—	21	124	〃 〃 0·08″ 〃 〃
—	8	30	〃 binding, 10′.
—	16	56	〃 forage, 12″.
—	4	17	〃 coupling, 15′.
			Various materials.
—	0⅛	0⅛	Logwood, lb.
—	—	6	Torches, pitch, 6 ft.
—	—	8	Grease, variolite, lbs.
1	—	6	Hair, cow and calf, lbs.
—	2	0¾	Charcoal, hard-wood, peck.
—	1	—	Coal, stone, cwt.
—	0⅛	0⅛	Glue, lb.
—	0⅛	0⅛	Pitch, black, lb.
—	0¼	0½	Tallow, ox, lb.
—	0⅛	0⅛	Wax, yellow, lb.

Gun.	P.	W.	Nature of Stores.
			Tools in general.
—	—	1	Smithy, mountain, set.
—	2	4	Axes, common, hand, with helves.
—	—	1	〃 wood 〃
—	1	1	Tools, farrier, shoeing, sets.
—	1	1	〃 saddler, sets, mountain [battery.
—	1	1	〃 smiths, do
			Furniture.
—	2	—	Locks, pad.
			The batteries have to make and keep up out of old material:—
—	2	2	Nuts, screw, No. 7.
—	10	4	〃 〃 〃 8.
—	2	2	〃 〃 〃 9.
—	2	2	〃 〃 〃 10.
			The batteries receive from the harness depot and have the care of the following stores, according to regulation.
—	—	2	Saddle, bridle, &c. complete, riding, Hungarian for N.C. officers.
—	1	2	Aprons, smith's, leather.
—	1	1	〃 saddler's, serge.

Lading mules and wagons.

10. The packing of all the mules belonging to a mountain battery and of the two wagons attached by a late order, the weight of the articles laden, and the order of march of the mules are detailed in the following table.

The mules are numbered in the following series according to the nature of the articles they carry :—

Mules.	Serial No.	Leader's No.	Nature of Stores.		Weight. lbs.
4 gun mules.	1, 2, 3, and 4.	1, 2, 3, and 4.	1 gun pack-saddle with head gear, horse-cloth, and 1 packing girth with line		58·8
			1 3-pr. rifled bronze mountain gun		191·4
			1 31″ handspike (in the bore)		2·3
			1 iron-shod lading lever, hung to the cascable		1·2
			1 tompion		1·6
			2 cartouches, filled with :—		
			1 tube pocket 1 friction tube lanyard } in the left hand	cartouche	
			1 tangent scale 1 priming iron 1 tangent scale and priming iron case 1 knee-cap 1 fuze-spanner and sling } in the right hand	cartouche	5·1
				Total	260·4

Mules.	Serial No.	Leader's No.	Nature of Stores.	Weight. lbs.
4 gun mules.	1, 2, 3, and 4.	1, 2, 3, and 4.	Sur-load { 1 small horse picket	1·0
			Sur-load { 1 hair bag with grooming gear, 1 front or hind shoe, 10 horseshoe nails, 1 nosebag, 1 halter chain (T)*	5·2
			Load of one gun mule	266·6
			The cartouches are hung by their load-straps on either side of the pack saddle.	
			The gun rides on the pack-saddle, muzzle to the right, and is secured by strap.	
			The packing girth in bivouac is to be used as a roller.	
4 gun carriage mules.	5, 6, 7, and 8.	5, 6, 7, and 8.	1 gun-carriage, pack-saddle, head gear, horse-cloth, and 1 wheel-bearer	62·3
			1 3-pr. plate iron mountain gun-carriage, complete	200·6
			2 recoil ropes	2·2
			2 sponges with rammers	6·2
			1 cartouche, filled with:— 1 clasp-knife and lanyard, 1 spare friction tube lanyard, 1 spare vent bit, 1 spare priming iron, 1 spare recoil-rope, 1 vent drift and hammer, 2, 10 ft. lashing lines.	7·6
			Total	278·9
			Sur-load { 1 small horse picket	1·0
			Sur-load { 1 hair bag, filled (T)	5·2
			Load of 1 gun carriage mule	285·1
			The gun-carriage, with the right side recoil rope attached, is placed trail to the rear on the pack-saddle and the protecting pad put under the trail; the wheels, having been taken off the axle, are hung with the large ends of the naves inwards on the wheel-bearer and axletree; one spoke resting on the axle, and one felloe on the wheel-bearer; the latter lying square across the cheeks of the carriage under the sponge. The other recoil-rope is passed under the upper felloes and once round the upper felloes of both wheels and then hooked to. Below, the wheels are secured by the wanty. Two sponges, heads to the front, are buckled on tight at the trail end and slack enough near the front of the carriage, to allow of the wheel-bearer being pushed in between the sponges and the cheeks of the carriage. One cartouche is placed between the cheeks of the carriage, in front of the elevating screw.	

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* The hair bag, in the above list marked (T) contains the necessaries for 1 mule; it weighs filled 5·2 lbs.

Mules.	Serial No.	Leader's No.	Nature of Stores.	Weight. lbs.
8 ammunition mules, 1st line.	9, 10, 11, and 12.	9, 10, 11, and 12.	1 ammunition and baggage pack-saddle, with head-gear, horse-cloth, 1 swing girth, and 4 suspending chains...	49·6
			2 ammunition boxes, common shell..........................	153·1
			Total	202·7
			Sur-load { 1 small horse picket	1·0
			1 hair bag, filled (T)	5·2
			Total	6·2
			Load of one mule from No. 9 to No. 12	208·9
	13 and 16.	13 and 16.	1 pack-saddle with appurtenances as above.................	49·6
			2 ammunition boxes, shrapnel shell..........................	155·6
			Total	205·2
			Sur-load { 1 small horse picket	1·0
			1 hair bag, filled	5·2
			Total	6·2
			Load of one mule from No. 13 to No. 16	211·4
8 ammunition boxes, 1st line.	14 and 15.	14 and 15.	1 pack-saddle with appurtenances as above	49·6
			2 ammunition boxes, case shot	130·9
			2 pickaxes, 2 shovels, with lashing lines....................	20·8
			Total	201·3
			Sur-load { 1 small horse picket	1·0
			1 hair bag, filled (T)	5·2
			Load of one mule, No. 14 and 15 :— Total	6·2
			The ammunition boxes are hung on the hooks of the pack-saddle by the suspending chains. Thus the wanty is buckled on each side to the lower rings on the ammunition boxes.	
20 ammunition mules, 2nd line.	17, 18; 19, 20; 21, 22; 23, 24; 25, 26; 27, 28; 29, 30.	17, 18, 19, 20, 21, 22, and 23.	1 pack-saddle with appurtenances as above.................	49·6
			2 ammunition boxes, common shell..........................	153·1
			Total	202·7
			Sur-load { 1 small horse picket	1·0
			1 hair bag with grooming gear, 1 front and 1 hind shoe, 20 horseshoe nails, 2 nosebags, 2 stall halter chains (on the odd-number mules of each pair (TT)*	7·4

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* The hair bag in the above list marked (TT) contains the necessaries for a pair of mules, and weighs filled 7·4 lbs.

Mules.	Serial No.	Leader's No.	Nature of Stores.	Weight. lbs.
20 ammunition mules, 2nd line.			Sur-load—*continued.*	
			2 days' forage for 2 mules :—	
			4 feeds of oats at 6·9 lbs. each	22·8
			1 corn bag, 1 peck	0·9
			2 feeds of hay at 12·3 lbs. each	24·7
			2, 12-feet forage ropes	1·2
			Total of each of the mules odd number	63·4
			Total of each of the mules even number	56·0
			Load of one mule Nos. 17, 19, 21, 23, 25, 27 and 29	266·1
			Load of one mule Nos. 18, 20, 22, 24, 26, 28 and 30	258·7
	31 and 32.	24	1 pack-saddle with appurtenances as above	49·6
			2 ammunition boxes, shrapnel shell	155·6
			Total	205·2
			Sur-load for mule No. 31, like No. 17	63·4
			Sur-load " " 32, " 18	56·0
			Load of mule No. 31	268·6
			Load of mule No. 32	261·2
	33	25	1 pack-saddle, with appurtenances as above	49·6
			2 ammunition boxes, case shot	130·9
			2 pitch torches, with lashing lines	14·7
			Total	195·2
			Sur-load as with mule No. 17	63·4
			Load of mule No. 33	258·6
	34		1 pack-saddle, with appurtenances as above	49·6
			2 ammunition boxes, shrapnel shell	155·6
			1 pitch torch, with 2 lashing lines	7·9
			Total	213·1
			Sur-load as with mule No. 18	56·0
			Load of mule No. 34	269·1
	35	26	As with mule No. 33	258·6
	36		As with mule No. 34	269·1
			The method of packing as above. The 20 mules numbered 17 to 36 carry two days' forage for themselves and for the 19 mules numbered 1 to 15, and Nos. 37, 38, and 39, and for one non-commissioned officer's horse.	

Mules.	Serial No.	Leader's No.		Nature of Stores.			Weight. lbs.
2 mountain forge mules.				1 ammunition and baggage pack-saddle with head gear, horse-cloth, 4 suspending chains, and 1 packing girth and line			49·6
			On one side,	1 leather mountain forge packing bag			9·3
				Inside of which is :—			
				1 mountain forge			79·6
				1 sheet-iron water sieve			2·2
				10 spare screw nuts			0·9
				¼ lb. steel			0·3
				Total			92·3
	37	27	On the other side,	1 leather packing bag for smith's tools			6·5
				Inside of which is :—			
				1 flat		punches.	1·7
				1 round			1·8
				1 square			1·7
				2 horseshoe			2·9
				1 8″		flat file	0·9
				1 12″			1·5
				1 1 lb.	smith's hand	hammer.	1·8
				1 2¼lb.			3·1
				1 8½lb.	sledge		10·7
				1 8½lb.			11·1
				1 coppersmith's			1·9
				1 12″ screw-plate			2·5
				1 drawing knife			1·6
				1 cold chisel			1·7
				1 medium nail swage			3·7
				1 hoof cleaner			0·9
				1 screwdriver			4·3
				1 8″ screw-tap spanner			0·5
				1 pair of pincers		forge	2·5
				1 „ tongs, small, hand			2·3
				1 „ „ medium			3·5
				30 horseshoes			23·0
				Total			92·2
				1 pickaxe and 1 shovel with lashing lines			11·0
				1 small horse picket			1·0
				1 hair bag, filled (TT)			7·4
				1 coupling rope, divided between the two mules			0·4
				Total			8·8
		27		Load of one mule, No. 37			253·2

Both pack bags are hung by the chains to the hooks of the pack-saddle; the two bags of charcoal are laid between

Mules.	Serial No.	Leader's No.	Nature of Stores.	Weight. lbs.
2 mountain forge mules.			the arches, above the saddle. 1 pickaxe and 1 shovel are tied, one on each side of the pack-saddle.	
			The two days' forage is similar to that of mule No. 33. The packing girths are to be used in bivouac as rollers.	
	38		1 ammunition and baggage saddle as above	49·6
			On one side, 1 leather bag for the vice and its fittings	7·1
			1 37 lb. vice	37·8
			1 hoof-support	6·0
			1 smith's poker	1·7
			1 " shovel	2·6
			1 water sprinkler	1·7
			1 " strainer	1·7
			1 farrier's bag, with tools	14·2
			1200 horseshoe nails	7·9
			Total	80·7
			On the other side, 1 leather bag for anvil and water bucket	4·2
			1 70 lbs. anvil	71·6
			1 sheet-iron oval water bucket	8·0
			1 " grease can	0·6
			Total	84·5
			¾ peck hard-wood charcoal in two small corn sacks	33·3
			1 pickaxe and 1 shovel with two lashing lines	11·0
			Total	44·3
			Load of mule No. 38	259·9
			Packing as before. The two days' forage similar to that of mule No. 34.	
Spare gun-carriage mule.	39	28	1 gun-carriage pack saddle, with head gear, horse-cloth, and 1 wheel-bearer	62·3
			1 3-pr. plate-iron mountain gun-carriage, complete	200·6
			1 31″ handspike	2·3
			2 recoil ropes	2·2
			1 cartouche, without partition, containing:— 1 tangent scale, 1 tangent scale and priming-iron case, 2 fuze-spanners with lanyards, 2 canvas bag hooks, 1 kneecap, 2, 10-ft. lashing lines	5·9
			Total	273·3
			2 small horse pickets	1·0
			1 hair bag, filled (TT)	7·4
			Total	8·4

Mules.	Serial No.	Leader's No.	Nature of Stores.	Weight. lbs.
			Load of mule No. 39	282·7
			The packing is the same as with mules Nos. 5, 6, 7, 8.	
			The spare handspike is carried between the cheeks of the gun-carriage.	
			2 days' forage as on mule No. 35.	
2 spare mules, saddled.	40	29	1 gun pack-saddle, with head gear, horse-cloth, and saddle, with surcingle	60·7
			4 sheet-iron cooking utensils with stew-pan	13·6
			Sur-load: 1 small horse picket..............................	1·0
			Sur-load: 8 feeds of oats at 6·9 lbs. each..................	55·6
			Sur-load: 2 corn sacks, 1 peck	1·9
			Sur-load: 4 feeds of hay at 12·3 lbs. each	49·4
			Sur-load: 4 12-feet forage cords	2·5
			Sur-load: 1 coupling rope, divided between the 2 mules	0·4
			Total	110·7
			Load of mule No. 40	185·0
	40		1 gun-carriage pack-saddle, with head gear, horse-cloth, and 1 wheel-bearer	62·3
			4 sheet-iron cooking utensils, with stew-pan	13·6
			Sur-load: 1 hair bag, filled (TT)	7·4
			Sur-load: in other respects as with mule No. 40	110·7
			Load of mule No. 41	193·9
			Both mules, Nos. 40 and 41, carry two days' forage for themselves, for mules Nos. 42, 43, and 44, and for three riding horses.	
2 ration mules.	42 and 43.	30	1 ammunition and baggage pack-saddle, with head gear, horse-cloth, 4 pack girths and lines, 4 packing splints, 4 pack rings, and 2 packing bags	66·4
			80 rations, 2·5 lbs. each (bread, tobacco, and salt) for 80 men for one day	197·5
			4 sheet-iron cooking pots, with stew-pan	13·6
			1 coffee-ration beaker	0·3
			1 billhook	3·7
			Total	281·6
			Sur-load: 1 small horse picket..............................	1·0
			Sur-load: 1 hair bag, filled (TT) on mule No. 43	7·4
			Sur-load: 1 coupling-rope divided between the 2 mules	0·4
			Load of mule No. 42	283·0
			Load of mule No. 43	290·4

Mules.	Serial No.	Leader's No.	Nature of Stores.	Weight. lbs.
2 ration mules.	42 and 43.	30	The load of the baggage mules is divided between two packing bags, so as to be of equal weight. In packing each packing bag, the following articles are made use of:— Two packing splints and 2 pack girths with lashing lines rove through the rear ends. The fore-ring ends of the packing girths are passed through the leather runners on the splint which is eventually to be next the mule, the splint being above the girths as they lie on the ground; the packing-bag filled is then laid on the splint; on the top of the bag the second splint is laid, its runners outward. The triangular packing rings are now run on to the packing girths and the latter passed through the runners of the upper splint; the lashing lines are then brought round the outside of the bag, passed through the fore end-ring of one pack girth, then back through the other; this is repeated several times, and finally the ends of the lashing line are knotted together. The side-loads thus prepared are hung on the hooks on either side of the pack-saddle by means of the chain-links attached to the triangular packing rings. The cooking utensils and stew-pan are hung over the horns of the saddle by a special girth strap.	
Officers' baggage mule.	44	31 Is likewise horse holder for one of the officers' horses.	1 ammunition and baggage pack-saddle, with head gear, horse-cloth, 4 pack girths and lines, and 4 packing rings	49·4
			Baggage for 2 officers, weight of package included	86·4
			Office papers and ration money, weight of package included	61·7
			Total	197·8
			Sur-load { 4 small horse pickets	4·0
			Sur-load { 2 hair bags, filled (TT)	14·8
				18·8
			Load of mule No. 44	216·6
			2 of the horse pickets and hair bag filled (TT) are for the two non-commissioned officers riding horses.*	

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* The totals of the above table (pp. 356–363) will often be found not to coincide exactly with the addition of the items: this is due to decimals lost in conversion from Austrian to British weights. All the figures are given to the nearest decimal.—*Tr.*

Lading of the wheel carriages of the mountain battery.

The following articles are laden on the wheel carriages of the mountain batteries :—

2-horse country wagons.	Nature of Stores.		Weight. lbs.
No. 1 wagon, with spare stores and rations.	*Stores of sorts.*		
	Spare harness, stable gear, and two pack bags		74·1
	Spare leather of sorts, rope ware, cow and calf hair in a large havresack, cleaning rags in a small havresack, mule shoes and nails	equally divided between two packbags.	66·7
	1 harness-blacking box, one grease box and contents		16 1
	1 pair of folding clams..........................		4·9
	1 leather cartouche with leather sling containing a complete set of saddlers' tools for mountain battery, save the clams, the rope-ware laid down in the list of stores for the saddlers' use, various materials and metals of sorts		22·2
	1 pickaxe, 1 shovel, 1 wood axe, 1 hand-axe, and 1 wooden drink keg		27·2
	Rations.		
	26 rations at 2·5 lbs. each (bread, tobacco, and salt) for the 13 men detailed to the train for two days (in one pack bag)		65·4
	93 meat rations for 93 men for one day (cut up and wrapped in brushwood)		61·7
	Reserve rations for 93 men at 1·35 lbs. (divided between two pack bags)		129·6
	Forage.		
	6 pecks of oats (48 rations) for all the horses and mules out of draft belonging to the battery for one day		345·7
	Baggage.		
	20 pairs of boots, spare (in one pack bag)....................		77·8
	1 cartouche with shoemakers' tools and uncut material ...		29·6
	9 cooking utensils with stew-pan and 2 coffee-ration beakers		29·6
	Sur-load.		
	4 days' forage for draft cattle, 1 corn sack (two pecks), and 1 hair bag (TT)		114·8
	Load of the first wagon, exclusive of the wagon's weight		1065·5

2-horse country wagons.		Weight. lbs.
No. 1 wagon, with spare stores and rations.	*Stores of sorts.*	
	1 pickaxe, 1 shovel, 1 billhook, 1 wooden drink keg	18·5
	Forage.	
	6 pecks (48 rations) of oats for all the horses and mules out of draft belonging to the battery for one day......	345·7
	48 bundles of hay at 12·3 lbs. each, for all the horses and mules out of draft for two days	592·6
	Sur-load.	
	4 days' forage for 2 horses or mules in draught, 1 corn sack (2 pecks), and 1 hair bag (TT).....................	114·8
	Load of the second wagon, exclusive of the wagon's weight	1071·6

Change from wheel draft to pack mules.

When the nature of the ground is such as to prevent wheel carriages from proceeding further, and when in extended operations it appears desirable that the batteries should be accompanied by four days' rations and spare stores, the wagons are to be placed in deposit at some convenient place, and saddled pack mules are to be used for the transport of the articles above mentioned.

For this purpose, in the first instance the four draft horses or mules are to be made use of, the pack saddles and other bât necessaries being demanded from the brigade ammunition park.

The other mules required are to be obtained in the country, or are to be pressed into the service. For a 3-pr. mountain battery the extra mules required are seven in number.

The packing of these mules is shown in the following table :—

Mules.	Serial No.	Nature of Stores.	Weight. lbs.
3 spare store mules.	45	Spare harness, stable gear, and 2 pack bags	74·1
		Spare leather of sorts, rope-ware, cow and calf hair, cleaning rags, mule shoes and nails	66·7
		1 harness blacking-box and contents	3·7
		1 pair of folding clams	4·9
		Total	149·4
		(Equally divided between two pack bags).	
		1 cartouche with saddlers' tools and material as previously detailed	22·2
		1 " " shoemakers' tools and cut-up materials...	29·6
		1 pickaxe, 1 shovel, 1 billhook	13·6

Mules.	Serial No.		Weight. lbs.
3 spare store mules.		2 days' forage for 1 mule	27·8
		Load of mule No. 45, without pack-saddle (This mule is led singly).	242·6
	46	93 meat rations for 93 men for 1 day, with packing	61·7
		26 rations at 2·5 lbs. each (bread, tobacco, and salt) for the 13 men detailed to the train for 2 days, in one pack bag	65·4
		1 billhook	3·7
		20 pair of boots, spare, in one pack bag	77·8
		Total	208·7
		2 days' forage for 1 mule	27·8
		Load of mule No. 46, without pack-saddle (This mule is led as 1 of a pair).	236·4
	47	Reserve rations for 93 men at 1·35 lbs., equally divided between two pack bags	129·6
		1 pickaxe, 1 shovel, 1 wood axe	18·5
		6 cooking utensils and stew-pan	19·8
		Total	167·9
		2 days' forage for one mule	37·8
		Load of mule No. 47, without pack-saddle (This mule is led with mule No. 46, as a pair).	195·7
8 forage mules.	48, 50, 52, and 54.	$3\frac{1}{8}$ pecks of oats equally divided in two large corn sacks	174·1
		4 days' forage for one mule	54·6
		Load of 1 mule, Nos. 48, 50, 52, 54, without pack-saddle	228·7
	49, 51, 53, and 56.	13 bundles of hay, at 12·3 lbs.	160·5
		4 days' forage for one mule	44·6
		Load of one mule, Nos. 49, 51, 53, 55, without pack-saddle	215·1
		Mules 48 and 49, 50 and 51, 52 and 53, 54 and 55, are led in pairs.	
		The method of packing is to be adjusted to the nature of the pack-saddle of the locality, and when feasible this should be practised in time of peace.	

Fig 5

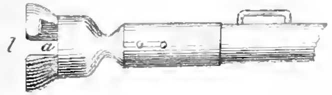


Fig 18

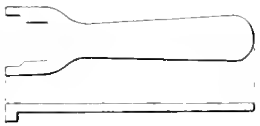


Fig 16.

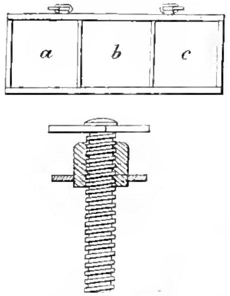


Fig 23

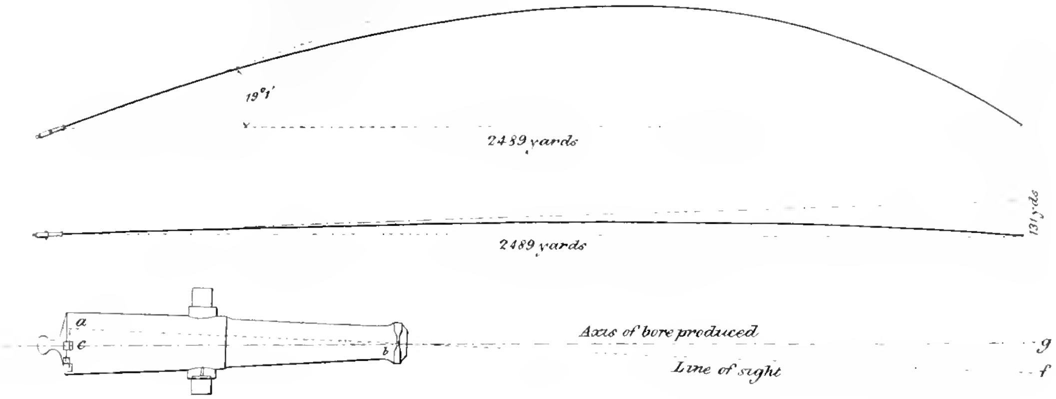


Fig 8c

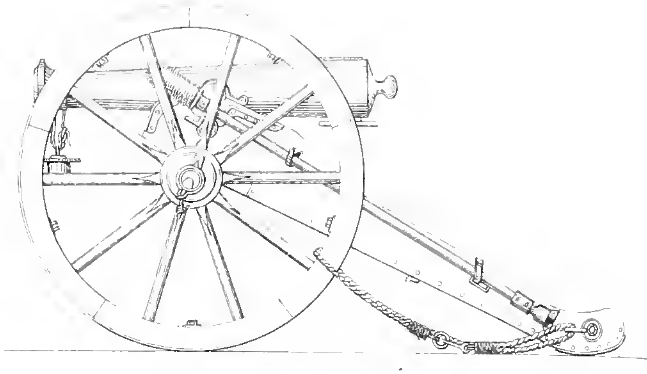


Fig 20

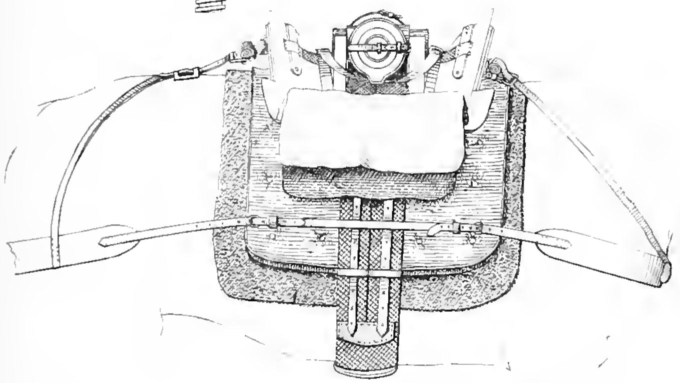


Fig 21

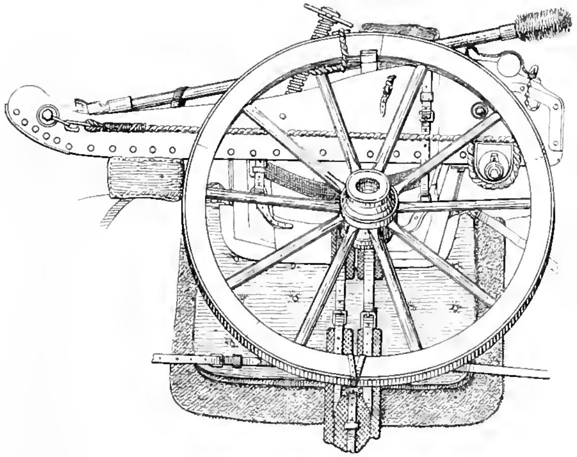


Fig 22

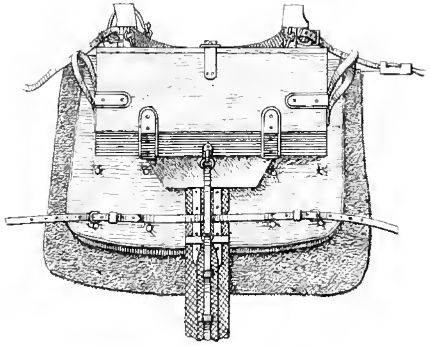
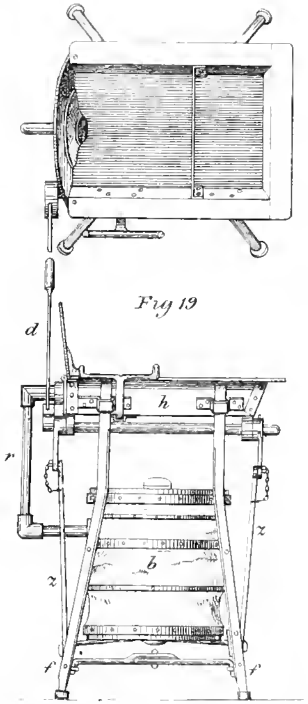
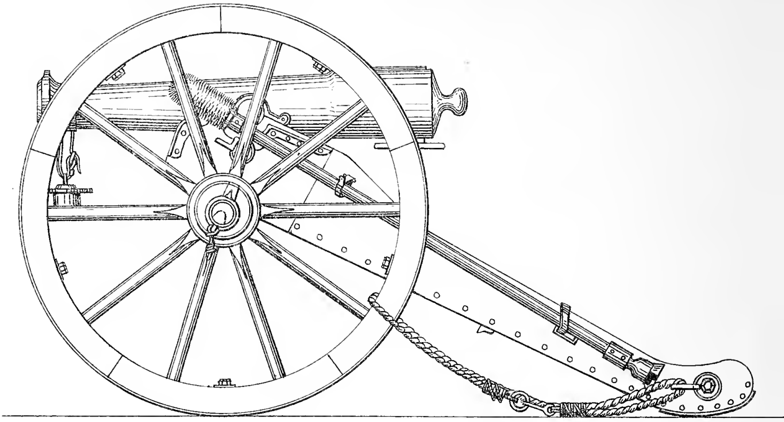


Fig 19



Lithographed at the Royal Artillery Institution

Fig 8c.



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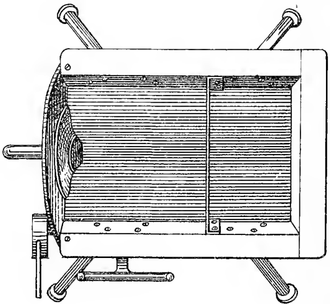


g 22.

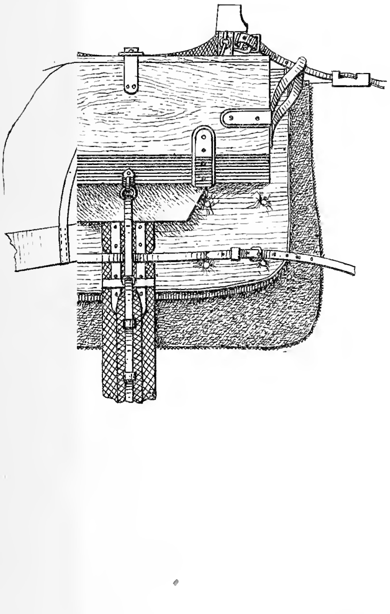
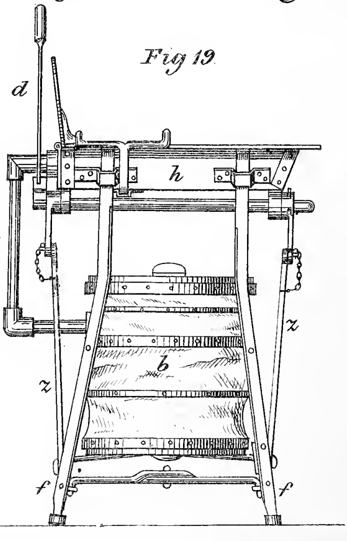


Fig 19.



Lithographed at the Royal Artillery Institution.

IV. The service, practice—its precision and effect—and the employment of mountain guns.

Service of the guns, gun-detachments and distribution of the gun implements.

11. The chief duties involved in the service of rifled mountain guns are:—lading, unlading, loading, unloading, laying, firing, and sponging out the piece.

For these duties, 5 men are told off to each gun; they are numbered from 1 to 5, and are provided with gun-implements as follows:—

No. 1: a cartouche, fuze-spanner with sling lanyard, handspike, the last of which he puts under the carriage when not in use; No. 2: a sponge and spare cartouche; No. 3: a tangent scale and priming-iron with a case for both, further a kneecap buckled to his right knee; No. 4: a tube-pocket and friction-tube lanyard; No. 5: a cartouche.

Lading and unlading the gun on and off the mule's back.

12. The gun and the carriage, as previously mentioned, are laden separately on mules' backs. For this purpose, the gun-mule is led up to the left of, and close to the gun; No. 1 puts the handspike into the bore; Nos. 2 and 4 undo the capsquares, the gun is then raised off the carriage, No. 1 lifting by the handspike, Nos. 3 and 5 by the cascable button and breech, the gun is then turned round on its axis until the vent comes downwards; by a further lift the gun is raised over the mule's croup and placed on the pack-saddle, the trunnions lying in their seats in the cradle, muzzle to the right. No. 1 stows the handspike in the bore and closes it with the tompion. Finally, Nos. 1 and 3 buckle to the gun straps while Nos. 1 and 5 buckling their cartouches together hang them square over the pack-saddle. In No. 1's cartouche are stowed the gun-implements of Nos. 1 and 3; in that of No. 5, the gun-implements of No. 4. Fig. 20 shows the packing of the gun-mule.

To lade the carriage, No. 2 buckles the sponge on the carriage, both sponges lying between the cheeks of the carriage, and with No. 4 runs the carriage up to its mule. Nos. 4 and 5 take out the linchpins and unship the wheels, laying them on the ground, put the linchpins in again, then lifting by the axletree arms, while No. 2 lifts by the trail, raise the carriage and place it on the saddle and trail-pad. Nos. 2 and 5 buckle the carriage straps, No. 2 puts the wheel bearer athwart the carriage; whereupon Nos. 4 and 5 hang on the wheels, dish outwards, one spoke over the axletree body, one felloe on the wheel-bearer, and fasten them above, by one of the recoil-ropes, below, by the wanty or swing girth. No. 2's cartouche is placed between the cheeks of the carriage and buckled fast. Fig. 21 shows the packing of the gun-carriage mule.

Unlading the gun is done in the reverse order; first the wheels and the carriage, and then the piece are unladen from their respective mules.

In unlading the gun carriage, No. 2 takes off his cartouche; Nos. 2 and 4 unbuckle the straps and cast loose the recoil-ropes, take off the wheels and lay them aside on the ground, No. 2 hands the wheel bearer and wanty to the mule leader; Nos. 2, 4 and 5 lift off the carriage; No. 2 lets the trail end fall to the ground; Nos. 4 and 5 take out the linchpins, ship the wheels, and put in linchpins.

In unlading the piece, No. 1 takes off his cartouche, unbuckles the tompion and buckles it under the muzzle, pulls the handspike partly out of the bore; Nos. 2, 3, and 5 lift the piece over the mules' croup, turn the piece on its axis until the vent comes upwards, and lay the piece on the carriage which has meanwhile being brought close by Nos. 2 and 4; finally, No. 2 keys on the capsquares.

The ammunition boxes are packed in pairs on the mules and are hung, one on the right, the other on the left side of the pack-saddle, by the suspending chains mentioned under the head of "Harness;" the wanty is then buckled to the rings attached to the bottoms of the boxes. Fig. 22 shows the packing of the ammunition boxes. As a protection from rain a canvas water-deck is put over both boxes.

Loading.

13. To load with common shell for firing at low angles, No. 1 enters the cartridge, tie outwards, into the bore, then the common shell bottom inwards, the short sides of the ridges in contact with the corresponding sides of the grooves, the nose drifts being just inside the bore. No. 2 fits the slots on the rammer head over the nose drifts and then rams home cartridge and shell. When home No. 2 turns the staff with a short sharp pressure to the right, thus turning the shell so that the broad surface of the ridges bears against the broad surface of the grooves, and so centering the shell in the bore. The rammer is then sprung out of the bore without turning it; meanwhile No. 3 pricks the cartridge.

The tin-foil band round the neck of the concussion fuze is not removed in loading.

In slow firing the cartridge and shell are rammed home separately.

In loading for firing at high-angles with common shell the cartridge is always set home by itself and the shell subsequently; to prevent the cartridge from turning over, the rammer head is adjusted over the tie end of the cartridge.

Shrapnel shells have their fuzes set to time before loading. To set the fuze No. 1 puts the base of the shell on the left cheek of the carriage, tears off the cap of the fuze, fits the studs of the fuze-spanner into the two recesses of the fuze cover and turns the plate and composition ring until the division of the scale corresponding to the range comes opposite the index on the fuze-body. The cartridge and projectile are entered in the same way as above described for common shells firing at high angles, with the exception that the shrapnel shell is put into the bore with the tin-foil covering over the priming of the fuze to the left and downwards.

Case shot, after the cartridge is put into the bore, are entered with the handle on the cover outwards; the cartridge and case shot are then rammed home together, the cartridge is pricked, and the rammer sprung. The turn of the rammer-head required with other projectiles is omitted with case shot.

After the gun is loaded No. 3 lays, No. 4 assists him at the trail, enters the friction-tube into the vent and fires; No. 5 supplies ammunition and hands cartridges and projectiles to No. 1 and friction-tubes to No. 4. In loading the first round only, No. 1 fetches cartridge, projectile, and friction-tubes.

With reference to taking out ammunition from the boxes, it is to be remarked, that generally speaking two cartridges and projectiles are to be taken out of the boxes by No. 5, taking care that the projectiles as far as possible are from the boxes on the right and left of the mule alternately. In quick firing, three cartridges and projectiles may be taken at once.

When the ground is such as not to admit of the gun recoiling, before opening fire the recoil-ropes are fastened to the wheels to check the recoil.

For this purpose Nos. 3 and 4, on their respective sides, unhook the front end of the recoil-rope from the advance-hook, pass the rope round one of the felloes of the wheel and attach the ring at its end to the hook on the opposite end of the rope: the hook end having been pulled through the ring at the trail of the carriage sufficiently for that purpose.

Unloading.

14. To unload a gun loaded with common or shrapnel shell, No. 2 enters the rammer into the bore up to the projectile, then turns the rammer to the left; by this means the nose drifts on the projectile are caught by the slots in the rammer-head. No. 2 then withdraws the projectile from the bore, turning the staff slightly to the left.

The easiest and quickest way of unloading case shot is to lower the muzzle of the gun, if necessary raising the trail. The ring on the cover of the case shot may be got hold of by the worm, and in this manner the projectile extracted.

Cartridges are invariably unloaded with the worm.

LAYING.

The trajectories of projectiles fired from rifled guns.

15. In order to explain the principles on which the laying of rifled guns is founded, it is necessary to devote some short considerations to the trajectories of their projectiles. As further, the interior construction of the projectile has an influence on the trajectory; we will first speak of the trajectory of the common shell, subsequently of those of other shells.

From the description of the ammunition we know that the gun has two sorts of cartridges, one for low-angle fire with a large charge, the other for high-angle fire with a small charge. Common shells are fired according to circumstances with the low or high-angle cartridges. The axis of the gun may either be horizontal, or inclined upwards or downwards to the horizon. When the gun is fired the common shell is set in motion by the force of the powder-gas; but in rifled guns, the shell can only move forward by at the same time following the right-handed twist of the rifled grooves: the common shell has thus imparted to it a motion of translation combined with one of rotation around its longer axis corresponding to the helical twist of the grooves. As long as the projectile is in the bore the motion of translation is in the direction of the axis of the piece and the velocities of the motions of translation and rotation increase in virtue of the continuous pressure of the powder-gas. At the instant the projectile leaves the bore it has attained a certain so-called initial velocity in the direction of the motion of translation, and at the same time a certain velocity of rotation round the longer axis. Outside the bore, gravity and the resistance of the air act on the projectile; hence in flying through the air it traces a curved concave to the ground at the same time diverging to the right, with reference to the axis of the piece; it is therefore a curve of double curvature. The common shell finally reaches the ground and bursts by the explosion of the bursting charge, whereupon the splinters of the shell proceed on in diverging paths, more or less curved. If the fuze or the bursting charge fail in effect, that is, if the shell is blind, the projectile may either lie where it falls, or proceed on its path in several bounds or ricochets generally very irregular in height and amplitude, until the velocity of translation becomes *nil.* The curve traced by the projectile outside the bore is termed the *trajectory;* the angle between the axis of the piece and the horizon is termed the *angle of elevation,* or of *depression,* according as its axis is directed above or below the horizon; further, the angle between the longer axis of the projectile just emerged from the bore and the horizon is termed the *angle of departure.* The horizontal distance from the muzzle of the gun to the intersection of the trajectory with a horizontal line through the centre of the muzzle is called the *horizontal range;* the angle between the tangent to the trajectory and the ground where the projectile falls is the *angle of incidence;* the angle formed by the line joining the point aimed at to the centre of the muzzle and the horizontal line through the former point is called the *ground angle;* finally, the deflection to the right from the vertical plane through the axis of the piece is termed the *drift;* this deflection with rifled guns has a certain amount of regularity.

The horizontal range, firing at low-angles, is dependent on the initial velocity of the projectile, on the action of gravity, on the resistance of the air, and on the angle of elevation of the piece. All other circumstances being alike, the horizontal range whether firing at low or high angles increases with the angle of elevation up to a certain limit; practically it is by the increase or decrease of the angle of elevation that the range is regulated to the distance of the object to be fired at.

The drift, or deflection to the right of the vertical plane of the trajectories of projectiles fired from guns rifled with a right-hand twist, depends on the range and on the velocity of the motion of rotation; it increases with a certain amount of regularity with the increase of both those factors.

The velocity of the motion of rotation depends on the initial velocity, which again is determined by the charge of powder, the weight of the projectile, and on the pitch of the rifling. The following table gives the initial velocity, the velocity of rotation, the drift and time of flight of common shells with low-angle charges:—

Table

SHEWING THE INITIAL VELOCITY, THE VELOCITY OF ROTATION, THE DRIFT AND TIME OF FLIGHT OF COMMON SHELLS FIRED WITH LOW-ANGLE CHARGES FROM THE 3-pr. MOUNTAIN RIFLED GUN.

Charge of powder, and weight of projectile.	Range.	Drift.	Time of flight.	Remarks.
	yds.	ft.	sec.	
The charge of powder weighs 7·4 oz.; the common shell weighs 4·289 lbs; ratio $\frac{1}{13\cdot6}$	415	·0	1·5	The initial velocity is 777·6 ft. per second; the velocity of rotation is 123·4 ft. per second; the number of revolutions of the common shell in the 1st second is 152.
	830	7·8	4	
	1659	99·5	9	
	2489	326·6	16·5	

The trajectories of shrapnel shells fired from rifled guns are similar to those of common shells up to the moment when the former burst by means of the time fuze and powder charge at a suitable height and certain distance from the object fired at. The initial and rotating velocities depend on the same conditions as have been mentioned with regard to common shell. At the point of the trajectory when the explosion of the bursting charge takes place, the shrapnel shell is shattered into a certain number of splinters; the splinters and the leaden balls contained in the cavity of the shell proceed on in diverging paths, until they reach the object fired at or strike the ground. The perpendicular height of the exploding shell above the ground is termed the *height of burst;* and the horizontal interval between the point on the ground directly below the burst and the object to be fired at is called the *interval of burst.*

The velocity with which the pieces of the shell or leaden balls begin their separate paths immediately after the bursting of the projectile is nearly the same as the velocity of the shrapnel shell the moment before bursting.

From observations made at experimental practice we are entitled to conclude, that, in comparison with spherical shrapnel shells, the velocity of rotation at the moment of bursting of elongated shrapnel shells gives rise to a rather greater spread of the splinters of the shell and the leaden balls.

Shrapnel shells have a rather smaller initial velocity than common shells, because the former weigh more than the latter, while the charge is the same. The drift of shrapnel shells differs from that of common shells in such a slight degree that it may be taken as identical.

Case shot from rifled guns, as from smooth-bores, are broken up in the bore by the shock of the explosion of the charge; the zinc shot are driven forward, each in a diverging curve, until they reach the object fired at or strike the ground; in the latter case, when the ground is firm and even, they continue their path of flight with several ricochets. The grooves have no influence over the trajectories of the case shot balls.

In general the main differences between the trajectories of elongated and spherical projectiles are as follows :—

(1) As the low-angle charge of powder of rifled guns amounts to between $\frac{1}{6}$th and $\frac{1}{7}$th of the weight of the projectile with field guns and between $\frac{1}{13}$th and $\frac{1}{14}$th with mountain guns; while with smooth-bores the ratio lies between $\frac{1}{3}$rd and $\frac{1}{4}$th (the common shell and round shot being taken at their normal weight); the initial velocities of the elongated projectiles are less than those of spherical projectiles.

With rifled guns smaller charges must be used, because elongated projectiles in addition to the motion of translation are forced to take a motion of revolution due to the twist of the grooves; this is only feasible when the impulse of the force of the powder which sets the projectile in motion does not exceed a certain limit. If the charge of powder, and consequently the impulse in the direction of the motion of translation to which the projectile is subjected, be excessive, the projectile has not sufficient time to follow the twist of the grooves; the guiding surfaces of the projectile are stripped, and the desired rotation round the longer axis does not take place.

As, further, the elongated projectiles of rifled guns are considerably heavier than spherical projectiles of the same diameter; if we wished to use as high charges as with smooth-bores, we should be compelled to increase the thickness and weight of rifled guns and their carriages, to enable the gun to stand the increase of work.

(2) The loss of velocity sustained by the projectile in its flight, consequent on the resistance of the air, is much less with elongated than with spherical projectiles; this result is due to the form of the former being better suited to overcoming the resistance of the air and to its mass being greater than that of the spherical projectile of the same diameter. The remaining velocities of elongated projectiles are consequently greater than those of spherical projectiles; the difference increasing with range. In consequence of the smaller loss of velocity, the trajectories of elongated projectiles at long ranges are flatter and effectively command more ground than those of round shot.

(3) It is well known, that the round shot of the smooth-bore gun during its passage down the bore bounds against the sides of the piece; that, due to the windage and the position of the varying centre of gravity, the shot leaves the bore rotating round a variable axis; and that, as the result of these circumstances, the regularity of the trajectories is materially and prejudicially affected. In the Austrian system of rifled guns, pattern 1863, the projectile is centred in loading (Fig. 6); it is forced by the grooves to retain that position while in motion inside the bore and simultaneously to assume a motion of rotation from left to right about its longer axis. Despite the windage of guns on this system, bounding of the projectile in the bore cannot occur as the bearing of the projectile is symmetrical. Hence the angle of departure is invariable; this circumstance in combination with rotation on a constant axis and in the same direction, essentially contributes to the regularity of the trajectory.

(4) The trajectories of spherical projectiles diverge to the right or left of the vertical plane through the axis of the piece, from the variation of the angle of departure and of the direction of rotation; those of elongated projectiles rotating to the right form a curve regularly diverging to the right of that plane.

(5) The ricochet of elongated projectiles is less regular than that of round shot; for the elongated projectile after the first graze varies in its position with reference to the resistance of the air; whilst the round shot invariably opposes a similar figure to that resistance.

Laying.

16. Laying a rifled gun (generally done before loading) involves two operations; giving the piece the required elevation or depression, and making the allowance for drift.

The object of elevating or depressing the gun is to give its axis a definite inclination to the horizon, thereby regulating the range to the distance of the object.

In making the allowance for drift, either the vertical plane through the axis of the piece is brought into the vertical plane through the object fired at, when the allowance is *nil;* or the vertical plane of the axis of the piece is set in a diverging position with reference to the object; this is generally speaking the case with rifled guns in consequence of the drift of their projectiles.

The two operations above alluded to are performed in one with mountain guns; the sight being taken either by line-of-metal or on the tangent scale.

Laying by line-of-metal.

17. In laying by line-of-metal the notched line on the breech and the notch of the muzzle sight are brought into one straight line with the object aimed at. In this position the axis of the piece is only elevated or depressed to the amount of the ground angle; and when the gun stands on horizontal ground and is laid as above described, the axis of the piece is in the same vertical plane as the object.

In laying by line-of-metal no allowance for drift is necessary, as at the short distances at which line-of-metal laying is used, the drift of the projectile is inconsiderable.

Laying by tangent scale.

18. We have seen in par. 6 that the tangent scale is so constructed as to afford the means of giving the gun the required elevation in conjunction with the requisite allowance for drift. As at most ranges at which the tangent scale is made use of, the drift of the projectile is so considerable that it cannot be neglected, even in firing at objects of considerable width; to hit a given point, the gun must not be laid directly on it, but just so much to the left as the drift is found to be to the right. As however this allowance for drift is at times too large to allow of the line-of-sight being taken on any part of the object; and as further it is extremely difficult to estimate with anything like accuracy on the object the amount of this allowance at long distances, the point to be hit is invariably the point aimed at, but the rear sight-notch is carried to the left proportionately to the amount of allowance to be made; this is effected by cutting the sight-notch in the traversing bar. When the rear sight-notch, thus carried to the left of the vertical plane through the axis of the piece, the muzzle or centre sight according to circumstances, and the point to be hit are brought into one straight line by moving the trail to the right; under these circumstances the requisite allowance for drift has been made, as may be seen by Fig. 23: *a* is the rear sight-notch, traversed to the left a distance *ac*, proportional to the drift *fg*; the point *a* is no longer then in the plane of the axis of the piece; *b* is the muzzle sight-notch, *f* the point to be struck, *abf* the line-of-sight, *cg* the axis of the piece produced. When the centre-sight is used and the foot of the tangent scale entered into the groove at the breech, the method of making the allowance for drift is similar.

In laying the gun by tangent scale, No. 3 selects the scale of divisions on the tangent sight in accordance with the nature of projectile and cartridge about to be used; he runs up the slider until its upper edge coincides with the division marked with the figures of the range in hundreds of yards; when using the scales on the front of the tangent sight, he slides the traversing bar to the left until the corresponding division on the drift-scale is visible at the left edge of the sight bar. The slider and traversing bar being thus adjusted to give the correct elevation and allowance for drift, the tangent sight is placed on the flat of the breech, when the divisions on the front are used; the sight is then taken over the upper V notch of the traversing bar and over the muzzle V notch directly on the object. These three points are brought into a straight line by working the elevating screw and traversing the trail sideways.

When the scales on the rear of the tangent scale are used, the foot of the scale is adjusted into the groove of the breech and the sight is taken over the upper V notch of the traversing bar and over the trunnion sight.

The following rules are to be observed in laying the gun at various ranges:—

(*a*) In firing case shot up to 166 yards inclusive, the sight is taken by line-of-metal. At 250 yards the slider is run down to the foot of the scale and the sight taken over the *upper* V notch of the traversing bar.

(*b*) In firing common shells at *low* angles up to and under 166 yards the sight is taken by line-of-metal. Between 166 and 250 yards the *lower* edge of the slider is brought in line with the division so marked and the sight taken through the *lower* V notch of the traversing bar. At ranges between 330 and 2499 yards the *upper* edge of the slider is brought in line with the appropriate division of the tangent scale, the sight being taken *over* the V notch on the upper arm. The divisions on the front of the scale are applicable to ranges up to 1660 yards, and from thence up to 2490 yards those on the back of the scale.

(*c*) In firing common shells at *high* angles the sight is always taken by tangent scale; from 420 up to 910 yards the scales on the front side are used; from 910 to 1490 those on the rear side are employed, the upper edge of the slider is brought to the appropriate division and the sight taken over the *upper* V notch of the traversing bar.

(*d*) In firing shrapnel shells at low angles from 250 to 1250 yards the divisions on the front side of the tangent scale are used; in this case the slider is invariably placed with its *upper* edge coinciding with the appropriate division of the tangent scale, and the sight taken over the *upper* notch of the traversing bar.

(*e*) The drift scales are used as previously described.

Laying on moving objects.

19. The rules above detailed refer to laying a gun when the object fired at is motionless.

If, however, the object is in motion, the method of laying must be somewhat modified.

If the object aimed at is advancing towards the gun, the gun should be laid lower than when the object is at rest; if the object is retreating from the gun, the gun should be laid higher; in other words, the elevation should be somewhat less or more than that appropriate to the distance at the moment of laying the gun.

Again, if the object is in motion across the line of fire, the elevation is not affected; but the piece should be laid to the right or left of the object according as the object is moving to the right or left; the amount of this allowance should be such as to result in the projectile and the object reaching the point aimed at, at the same instant.

In firing at objects of considerable width laying the gun to one side is unnecessary; if the object is a column of troops for instance, the gun is laid at the head of the column, and thus the projectile will strike somewhere to the rear of the front.

The allowance to be made in laying at moving objects depends on the time of flight of the projectile and the rate of motion of the object: on service the latter can only be roughly determined. This is however of trifling importance when we recollect that common and shrapnel shells effectively command a considerable width of ground by their explosion; generally speaking it is only when the object is in quick and continuous motion that allowance need be made in laying.

With reference to the service of the 3-pr. rifled mountain gun, it remains to be stated that to transport the gun on its carriage for a short distance, No. 4 takes a recoil-rope off the carriage, hooks the ring at one end to the hook at the other, then reeves the doubled rope through the trail ring. The handspike is placed through the sling so formed, and Nos. 1 and 4 drag the gun by it, whilst Nos. 2 and 3 lend a hand at the front of the carriage or spoke the wheels. We understand that shafts are shortly to be introduced for facilitating the transport of the gun on its carriage.

Firing.

20. While the gun is in process of being loaded, No. 4 bends down the loop of the friction-tube wire and attaches it to the hook of the lanyard. As soon as the gun is loaded and laid, he puts the tube into the vent and draws the lanyard taut with his left hand; when the word "Fire" is given, he strikes the lanyard a smart blow with his right hand; thus the rubber is drawn out of the friction tube and the tube and cartridge ignited.

Sponging.

21. Sponging is the duty of No. 2; he enters the sponge, runs it up to the bottom of the bore, gives it a few turns to catch any residue of cartridge which may have been left in the bore and withdraws the sponge to fetch it out. Meanwhile No. 3 serves the vent with the thumb of his right hand in order to extinguish any spark which may exist in the bore.

No. 3 passes the priming iron down the vent to see that it is clear. If the vent is choked by a remnant of the cartridge, it is cleared if possible with the priming iron: if this fails, it is driven into the bore with the drift and hammer: it is then brought out by the sponge.

When the gun has not been used for some time or when it may be supposed that there is some dirt in the bore, the gun is sponged and the vent searched before loading. When circumstances admit, on ceasing fire the adherent powder slime is washed out with water and the gun sponged out with oakum.

PRACTICE. (*a*) *Species of fire.*

Nomenclature of the various natures of fire of mountain guns.

22. The various natures of fire of mountain guns are named according to the form of trajectory, the projectile fired, the charge of powder, the manner of laying, the incidence of the projectile, or the effect intended to be produced.

The various natures of fire according to the form of trajectory.

23. In firing at low angles the normal charge of powder is used; a distinction is made between the two halves of the extreme range; the fire for ranges included in the first half is termed "flat fire;" that for ranges in the other half is called "curved fire."*

In firing at high angles the smaller cartridge is used, and the elevation is always considerable.†

Ricochet fire, in which the projectile rises after grazing and bounds forwards, is not intentional with rifled guns: usually it occurs with case shot and with common and shrapnel shells only when blind.

The various natures of fire according to the projectile and charge used, and the method of laying.

24. According to the nature of projectile, the fire is variously termed common shell fire, shrapnel fire, and case shot fire. The trajectories of those projectiles are similarly entitled.

According to the charge of powder used we have full charge fire or reduced charge fire.

Taking the denomination from the manner of laying, the fire is called line-of-metal fire and tangent scale fire. The former is in use up to 166 yards, the latter at all longer ranges.

The various natures of fire according to the direction in which the projectile strikes the object.

25. Under this method of distinction we have perpendicular, oblique, direct, and indirect fire.

In perpendicular fire the longer axis of the projectile forms equal angles, to the right and left, with the front surface of the object; in oblique fire these angles are unequal.

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* This distinction is unknown in the British service.

† In the original, the above two paragraphs contain definitions of two terms unknown in the British service. The style of fire in the first paragraph is termed "Shooting," in contradistinction to that in the second, which is termed "Throwing."

Direct fire is when the projectile without grazing strikes an upright object not under cover. Indirect fire is when the object fired at is under cover, or when the projectile strikes the object after having grazed.

To the above must be added, cross-fire when the lines of fire of several guns aimed at the same object cross each other; and diverging fire, when a number of guns in one battery fire at different objects.

The use of the various natures of fire will be spoken of under the head of mountain guns in action.

(*b*) *Extreme ranges, and probability of a hit.*

Extreme ranges.

26. By extreme ranges is meant the furthest limit of the trajectories of the different projectiles: they are as follows:—

For common shell, low-angle fire......	2490 yards.
" " " high "	1490 "
" shrapnel " low "	1250 "
" case shot...... " "	250 "

Circumstances upon which the probability of a hit depends.

27. A given object is struck by a projectile, when the trajectory of the projectile intersects the object. In order then that each projectile fired should hit the object at a certain range, all the trajectories must be identical, or only slightly differing, according to the size of the object fired at. We know from experience that the trajectories vary under apparently similar conditions; seeing that they are influenced by elements whose nature and amount of effect can neither be accurately ascertained or taken into account. We cannot therefore with the best made guns and under the most favourable circumstances reckon on absolute certainty, but merely on a certain probability of a hit.

In par. 15 we have seen, as regards smooth-bore guns, that the effect of the windage, the possible rotation of the spherical projectiles on different axes and in different directions as well as the variation in the angles of departure, are prejudicial to the regularity of the trajectories; further, that with rifled guns these circumstances prejudicial to the probability of a hit are in a great measure got rid of by the steady bearing in the grooves and regular rotation of the projectile.

Besides the above-mentioned there are yet other elements which affect the trajectory of the projectile and which are prejudicial to the probability of hit of rifled and smooth-bore guns alike; they are as follows:—

(1) The ammunition as manufactured is not precisely identical; the powder is affected by atmospheric influences and by jolting in transport. The amount of force evolved varies with the quality of the powder, resulting in variation in initial velocity, and range. The force of the powder is to a certain extent dependent on the temperature of the gun when fired, for it is a well-ascertained fact that with a gun heated by long firing greater ranges are obtained than with a gun which is cold on opening fire. The resistance sustained by the projectiles in their flight through the air is often modified by the temperature and density of the atmosphere; it thus happens, that on a warm day with a low barometer greater ranges are obtained than on a cold day with a high barometer.

From the varying quality of the powder, from the varying resistance of the air on different days, from the inevitable inequalities in the weight and in the position of the centre of gravity of the projectiles, there result certain irregularities in the trajectories, even with rifled guns, which it is impossible to avoid.

(2) The guns as manufactured are not perfectly identical; hence too arise certain differences in the trajectories. Experience has shown that out of a batch of perfectly new guns, firing equal charges, with the same elevation and atmospheric circumstances, some shoot further and others shorter than they should under the given conditions. The peculiarities of each gun, then, should be ascertained, so as to discover how far the elevation and allowance for drift for each range as ascertained by calculation agree. This peculiarity again is to a certain extent prejudicial to the probability of a hit.

(3) Bronze rifled guns wear from the friction between the driven surfaces of the projectile and the driving surfaces of the piece; the wear increases by long service and gradually diminishes the probability of a hit. Although the endurance of bronze guns may be said to be perfectly satisfactory, still the above circumstance must be borne in mind in questions of probability.

(4) The gun is not always laid with the same accuracy and uniformity at practice, still less so before an enemy; this, once more, introduces variation in the trajectories and therefore is prejudicial to the probability of a hit.

(5) The estimation of the distance of the object to be fired at is difficult at short and much more so at long distances; usually the estimate is more or less erroneous; the error thus introduced extends to the elevation of the gun and the allowance for drift, and finally, to the trajectory; thus the probability of a hit is diminished.

(6) A wind blowing in a direction non-coincident with the line of fire exerts a more prejudicial influence on the elongated projectiles from rifled guns than on the round shot of smooth-bores, inasmuch as the former projectile opposes a larger side surface to the wind, and consequently deviates more from the intended direction.

(7) With shrapnel shells the probability of a hit of the splinters of cast-iron and bullets depends chiefly on the regularity of the burning of the fuze; the rings of composition of the latter vary in time of burning; this is partly due to the varying condition and density of the composition, and partly to the temperature and hygrometricity of the atmosphere: these variations are more particularly observable at long ranges.

(8) The more extended range of rifled guns lessens the probability of a hit so far, that the various influences which cause divergence of the projectile have a longer time to act upon it, and consequently cause greater irregularity.

After having thus detailed the various elements affecting the probability of a hit, we have now to show the actual probability of the mountain gun.

The probability of a hit may be estimated, either by the ratio of the number of hits in a given object at a certain distance to the number of rounds fired; or by the dispersion of the first grazes, both as to length of range and width of side deviation.

The following tables, the results of experimental practice, give the necessary information as to the probability of a hit of the various projectiles fired from the 3-pr. mountain gun.

TABLE

SHOWING THE PROBABILITY OF A HIT WITH 3-pr. COMMON SHELLS, LOW-ANGLE FIRE.

Elevation.		Mean range.	Horizontal target, 1st graze. Dispersion.				Vertical target, hits per cent. in a target 35 yds. × 4 yds.	Length of ground effectively commanded for a 6·2 ft. object.	Remarks.
			Length.		Width.				
			Maximum.	Mean.	Maximum.	Mean.			
°	′	yds.	yds.	yds.	yds.	yds.	No.	yds.	
1	24	415	50·6	11·6	1·66	0·91	91	62	Charge 7·4 oz.
3	47	830	54·0	14·1	4·56	1·58	67	26	
6	21	1244	62·2	17·4	7·47	2·24	43	12	
9	26	1659	73·8	21·6	10·79	2·90	20	8	
13	36	2074	90·4	29·9	14·10	3·73	10	8	
19	1	2489	110·3	61·4	17·84	4·65	—	5	

The mean range is the arithmetic mean of a number of ranges obtained under like circumstances.

The maximum dispersion in length is the difference between the greatest and least range of a series of rounds fired under like circumstances.

The mean dispersion in length is the arithmetie mean of the differences between the mean range and the actual range.

The maximum dispersion in width is the difference between the greatest and the least deflection, when the deflections in a series of rounds are all to the same side; or the sum of the greatest deflections right and left.

The mean or parallel deflection is the arithmetic mean of the whole of the deflections in one series of rounds, when the deflections are all on the same side. When the deflections are on both sides, the mean deflection is obtained by adding the deflections to the right and those to the left into two separate sums, subtracting one from the other and dividing the difference by the number of rounds. In the first case when the deflections are all to one side, the parallel deflection is termed right or left deflection according to the side to which the deflections have occurred. In the second case the parallel deflection bears the name of the side to which the greater of the two sums appertains.

The mean dispersion in width is the arithmetic mean of the differences of the mean deflections and all the observed deflections of the series of rounds.

TABLE

SHOWING THE PROBABILITY OF A HIT WITH 3-pr. COMMON SHELLS, HIGH-ANGLE FIRE.

Elevation.		Range.	1st graze. Dispersion.				Hits per cent. in a square of the undermentioned dimensions of a side.		Angle of incidence.	Remarks.
			Length.		Width.					
			Maximum.	Mean.	Maximum.	Mean.				
°	′	yds.	yds.	yds.	yds.	yds.	66 yds.	33 yds.	°	
3	10	415	54·8	23·2	2·49	1·43	75	50	6½	Charge 3·7 oz.
8	20	830	63·1	24·1	4·98	0·37	64	36	12	
14	5	1244	78·0	25·7	8·30	4·18	44	30	20	
18	8	1493	90·4	26·5	11·50	5·97	45	25	28	

Table

OF PRACTICE OF THE 3-pr. SHRAPNEL SHELLS, SHOWING THE HITS IN 3 WOODEN TARGETS PLACED 41 yds. APART, EACH MEASURING 35 yds. LONG BY 4 yds. HIGH.

Elevation.	Range.	Mean bursting.		Through hits in all three wooden targets. Mean per round.			Ground effectively commanded.			Remarks.
							Length.		Breadth.	
		Interval.	Height.	Leaden balls.	Pieces of shell.	Leaden balls and pieces of shell.	Short distance.	Long distance.	Short and long distance.	
	yds.	yds.	ft.				yds.	yds.	yds.	
2° 2′	415	26	11·4	50	16	66	166 to 250	124 to 207	41	The 3-pr. shrapnel contains 55 leaden balls, 26½ to the lb.
4 7	830	38	12·4	48	17	65				
6 50	1244	22	13·5	39	16	55				

Table

OF PRACTICE OF 3-pr. CASE SHOT, SHOWING THE HITS IN 3 WOODEN TARGETS PLACED 41 yds. APART, EACH MEASURING 35 yds. LONG BY 4 yds. HIGH.

Range.	Number of hits in the first target, per round.				Number of hits in all three wooden targets, per round.				Remarks.
	Through.	Struck.	Total.	Per cent. of through hits.	Through.	Struck.	Total.	Per cent. of through hits.	
yds.									
166	14	—	14	40	25	4	29	72	The 3-pr. case shot contains 34 1·8 oz. balls. The ground effectively commanded is 332 yds. long by 83 yds. wide.
249	13	1	14	40	22	7	29	64	

Effect of the 3-pr. projectiles.

28. The common shell either takes effect by its percussive force on reaching the object, or by the explosion of the bursting charge; in the latter case the effect may be either like case shot or a small mine.

The percussive force of the common shell depends on the weight of the projectile and its remaining velocity: practically some idea of the amount of this force is attained by the penetration of the shell into or by the amount of injury done to the object fired at. It is to be remarked, that the form of the nose of the shell, the proportionately large mass to small diameter and the great remaining velocities are much in favour of both penetration and destructive effect.

No experiments have been made as to the amount of penetration of the 3-pr. common shell in earth and woodwork, &c., and as to its mine-like effect. Nevertheless we may accept it as a fact that the 3-pr. common shell may be used effectively against objects of no great strength, such as wooden roofs, &c., and that its percussive force is sufficient so far to injure a gun or its carriage as to put it *hors de combat.*

As to the case-shot like effect of the 3-pr. common shell, the following table gives full information; it should be added, that for a maximum effect the fall and burst of the projectile should take place within a few yards of, or absolutely in the object.

TABLE

OF THE HITS OF THE SPLINTERS OF THE 3-pr. COMMON SHELL, FIRING AT 3 WOODEN TARGETS 41 yds. APART, MEASURING 35 yds. LONG BY 4 yds. HIGH.

Range.	Distance of graze of shell from first wooden target.	Number of hits			Remarks.
		In the first.	In the second and third.	Total.	
yds. 414	yds. 29	8	3	11	A 3-pr. common shell with a bursting charge of 4·8 oz. breaks up into 2 large, 13 medium, and 20 small splinters. The small splinters weigh 0·6 to 1·8 oz.; the medium 1·8 to 3 oz. The splinters effectively command a space of from 124 to 330 yds. long by 124 to 166 yds. wide.
830	21	6	2	8	
1244	33	4	2	6	
1659	23	3	1	4	

The effect of the shrapnel shells and case shot is to be found in the data of par. 27. The 3-pr. shrapnel shell exploded by its charge of 1·7 oz. bursts into

32 small splinters,	weighing	from	0·3	to	1·8	oz.
8 medium	"	"	1·8	"	3·7	"
2 large	"	"	6·2	"	14·8	"

giving a total of 42 effective splinters, not reckoning the bullets (55) in the shell.

(c) EMPLOYMENT.

Conditions under which mountain guns can be employed.

29. For mountain guns to be of real service, the first condition is that the gun should be transportable on mule-back without difficulty over every sort of ground in a mountainous country. After feasibility of transport, the second condition is its efficiency, or power; and, as the third, adequate equipment of ammunition.

The dimensions, weights, the arrangements connected with facility of taking to pieces and putting together, of lading and unlading the 3-pr. mountain gun and carriage, have been settled after numerous experiments; as a result the system has attained the maximum of portability compatible with adequate efficiency.

The load of 272 lbs., the average load for each mule, is not excessive even with mules of an inferior stamp. The gun, too, can be dragged a few hundred yards by its detachment without any great effort, as has been explained in par. 19.

Batteries of this new *matériel* have been marched for experiment and before the enemy, and they have nowhere been brought to a stand-still; but the necessity of shafts for the transport of the gun on its carriage has been felt, and a decision by superior authority on this point is awaited.

When portability is the first and most essential element in a piece of artillery, as is the case with the mountain gun, we can only expect from it an amount of power, as the second factor, compatible with the fulfilment of the first condition. Moreover, from the nature of mountain warfare, the power and range of a gun can only be brought to bear on an enemy within generally speaking very restricted limits. From the table we see that the common shell of the 3-pr. mountain gun fired at a low angle gives a great probability of a hit up to 850 yards, and a satisfactory probability up to 2500 yards; that, high-angle fire of that projectile is efficient up to 1500 yards; that shrapnel fire up to 850 yards gives numerous hits, and up to 1250 yards a satisfactory number; that case shot is effective up to 250 yards. When we compare the above with the well-known trifling effect of the 12-pr. mountain smooth-bore howitzer formerly in use, we conclude that the introduction of the 3-pr. rifled mountain gun must be pronounced to be a step essentially increasing the efficiency of the arm in mountain warfare.

As the equipment of ammunition of the 3-pr. rifled gun battery, a supply of 448 rounds per battery, according to all experience, is amply sufficient for the battery to keep up a continuous and oft-repeated fire; further it is to be recollected that the greater accuracy of the rifled gun involves a less expenditure of ammunition than with the smooth-bore.

Selection of the object to be fired at; the nature of fire to be employed; the position of the gun; correction of the laying.

30. The selection of the object to be fired at depends on the intention of the engagement; that intention should therefore be communicated to the commander of the battery or should be sufficiently obvious from the circumstances attending the engagement.

In addition to the above, there are other circumstances affecting the selection of the object to be fired at, partly dependent on the various ways in which artillery is made use of, and partly on the progress of and condition of affairs in the engagement.

In general the following points bear on the selection of the object to be fired at:—

(1) Each detachment of guns, whether it consists of two or three guns, or of one or more batteries intended to co-operate, should generally speaking select but one object to fire at, and that should be such as the intention of the engagement marks out for destruction or injury. Cannonading several objects simultaneously delays a result and enfeebles the total effect; under such circumstances, the moral effect produced by a concentrated fire of artillery on one point due to the great increase of such a fire in mechanical effect, is lost. This rule is more especially applicable to mountain artillery, for the number of guns engaged is always small, and dispersion of fire all the more to be avoided.

(2) When the intention of the engagement is not obvious and there is consequently no determined object to be fired at, and yet the guns have to come into action, they should fire at such of the enemy's troops as appear by their distance, formation, and the nature of the ground to give the greatest probability of a hit; or at such of them as are likely the soonest to have an influence on the course of the engagement.

(3) In the case of artillery supporting infantry in attack on defences at the commencement of an engagement, fire should be opened on the enemy's guns, in order as far as possible to silence their fire and to protect our troops from great loss. When this object is as far as possible attained, the artillery fire should be directed on the troops to be attacked or on those from which an attack is anticipated.

(4) When detachments of the enemy's artillery are on the march, or, in general terms, when they are in such motion or position as to expose a long and nearly unbroken body favourable for artillery fire, the fire should be directed to the enemy's artillery; provided that the intention of the engagement at that particular period is not such as to demand an exclusive and powerful cannonade on some other object.

As to the employment of the various natures of fire of the 3-pr. mountain gun, the following rules should be observed.

Low-angle fire of common shell should be employed:—

(1) Against troops and guns at ranges up to 2500 yards; yet a range of 850 yards is the limit of a large percentage of hits; consequently at greater ranges, especially at 1600 yards, fire should only be directed on large bodies of troops and the practice carefully watched.

(2) To destroy wooden buildings and other objects encountered in mountain warfare; if these objects are very strong their destruction can only be effected by a large expenditure of time and ammunition: under such circumstances it is well to endeavour to get at the inside of the object by firing at the natural appertures, such as windows and doors, and thus to drive the enemy out of them. To effect such a result in a short time the range should not exceed 650 yards.

High-angle fire of common shells is used at ranges between 400 and 1600 yards against troops and guns under cover of the natural ground or of intrenchments. This species of fire is frequently employed in mountain warfare. With the rifled 3-pr. it promises to give the best results, as the probability of a hit with high-angle fire is remarkable. At ranges beyond 1600 yards low-angle fire should be employed with common shells, because the trajectory of that projectile at long ranges is highly curved consequent on the proportionately small charge of the piece.

Shrapnel shell fire is employed against troops in deep formation or in line between 250 or 850 yards, and even up to 1250 yards in cases of necessity. It may be successfully employed against troops under low cover between these ranges; generally speaking, however, common shells with high-angle fire are preferable under such circumstances.

To get good results from shrapnel fire, accurate estimation of the distance and a burst of projectile at a short interval in front of the object, are indispensable: consequently, on the defensive when the range and deflection, and hence the elevation, deflection and length of fuze can be determined beforehand, this projectile should be made use of. On the offensive, it may be employed when a continuous fire is to be kept up, the distance being ascertained by a few rounds of common shell.

Case shot fire, as with field guns, is chiefly applicable when on the defensive, against troops at short distances up to ranges of 250 yards as a maximum.

With reference to the positions to be taken up by mountain guns, the following points should be specially attended to:—

(1) The ground on which the guns stand should as far as possible command the country in front, with an uninterrupted view up to 850 yards at least; that distance being the limit of the most effective practice.

(2) The soil on which the wheels and trails rest should be even and not too hard, in order to save the carriages; hence, positions on rocky ground should be avoided if possible.

(3) Particular attention should be paid to security from surprise, for in mountainous country it is often practicable for an enemy to steal up unseen and thus make a sudden attack. Mountain batteries, therefore, should always have a tolerably strong escort of infantry detailed to them; part of the escort should remain in the immediate neighbourhood of the guns, and the remainder occupy the paths or other means of access to the position to the flanks and rear, when the paths are not visible from the battery.

(4) The ammunition mules not wanted in the immediate neighbourhood of the guns and which follow in the second line, are placed under cover. Covered positions are taken up or thrown up for the guns and mules immediately connected with guns; this is often feasible in mountains, especially when the ground is not very hard and intrenching tools can be used.

Observation of the practice.

31. At practice the distances generally speaking are incorrectly estimated; the error is transferred to the laying of the gun and the timing of the fuze; further the trajectories of projectiles are modified by variation in condition

of the different bores, and of the ammunition, and more especially by atmospheric influence; thus, in many cases, the elevation and length of fuze do not correspond: hence, the first round should always be considered as a *trial shot*, and *it should be carefully observed;* by this means the necessary corrections in elevation, deflection, and in length of fuze can be ascertained.

The figures on the tangent scale and on the time scale of the fuze should not be looked upon as *invariable rules* for laying the gun and timing the fuze, but merely as starting points for the first round from a gun in a certain position.

In firing common shells the spot where the projectile first strikes the ground, and in firing shrapnel shells the bursting interval and height of burst should be watched. With the former projectile, the observation will be much facilitated by adopting the old artillery rule, of giving less elevation for the first round than appears necessary for the estimated distance, so that the first graze should be in front of the object. The position of the first graze as regards range is best judged from one side of the piece; and as regards deflection, from a point immediately behind the gun in the line of fire: the former position should be taken up by the commander of the detachment of guns; the latter by one of the numbers serving the piece.

The explosion of the common shell on first graze clearly indicates the spot where the shell strikes. Under favourable conditions of atmosphere and with a somewhat practised eye, a shell fired at a high-angle can be seen during almost the whole of its flight.

The height and interval of burst of shrapnel shells are best judged of from the side of the piece; for this purpose the elevation for the first round should be somewhat greater and the timing of the fuze somewhat less than is applicable to the estimated distance.

Correction of the laying of the gun, and of the timing of the fuze.

32. Agreeably to the above directions on opening fire, the first two or three rounds should be fired with the elevation and timing decided on; a pause should be allowed between each round, so that the first graze and burst of the projectile may be observed leisurely. The elevation and deflection in firing common shells is then corrected according to the position of the first graze. If the projectile goes obviously too short or too far, the correction may be applied at once; if however the range is not considerably greater or less than the distance of the object, it is advisable to make no correction until after the second round. If the projectile at the first round strikes short of the object, and at the second at or beyond it, no correction is necessary, because such errors are not to be corrected by alterations in laying the gun.

If the shrapnel shell bursts after grazing either far before or beyond the object, the distance of the object has been considerably under or over estimated; the elevation and timing are in the first case to be increased according to the observation, and in the second decreased.

When the suitable elevation has been ascertained so closely, that it might be presumed that the shrapnel shell, if it did not burst, must strike in the immediate neighbourhood of the object, the height and interval of burst, if found too little or too great, can be corrected by the timing. In this matter, the following rule holds good, that shortening the time of burning of the fuze simultaneously increases the interval and height of burst; by increasing the time of bursting, the interval and height of burst is decreased.

After the trial shots, when the fire is to be continued with corrected elevation and timing, the further observation of the shells should not be neglected, and corrections should be made in case of considerable error.

In correcting the laying and timing the natural dispersion of the shots and the difference of times of burning of fuzes, given under the head of probability of a hit, should be borne in mind; for errors lying between the limits therein stated cannot be amended, and corrections attempted under such circumstances may lead to greater deviation.

Conduct in action of mountain batteries.

33. The 3-pr. rifled mountain batteries are usually attached to brigades of infantry intended for mountain service, and are placed under the command of the Brigadier.

The conduct in action of a mountain battery is guided generally by the same principles as obtain with field artillery. The following points are of particular importance:—

(1) The selection of suitable positions for guns, and taking advantage of the ground, is more difficult in mountainous than in an open or slightly intersected country; it requires special dexterity, experience, and a sharp and practised eye, accustomed to the peculiarities of mountain formations; these the battery commander must attain by study of the ground, so as not to lay himself open to repeated surprises and embarrassments without end in the command and employment of his battery on service.

The best method of practising and preparing such batteries for service is to quarter them in mountainous localities in time of peace.

(2) When a mountain brigade in advancing comes upon an enemy and it is decided to attack him, the guns are immediately unpacked and put together. The battery commander, having received his instructions from the Brigadier, meanwhile selects a position for the battery such as to enable it to develop a satisfactory fire, and such that its fire shall be liable to interruption by the advance of the infantry at the latest possible period. The guns are then brought up to the position by the detachments and open fire. Eight ammunition mules only are to be taken to the front, the others being placed under cover to the rear.

The range, as a rule, should not exceed 850 yards. A much nearer approach to the enemy is only admissible when the ground on which the battery stands is unfavourable, or when it becomes necessary for the protection of our own troops: for at the above distance the 3-pr. mountain gun can act most efficiently.

The first two or three rounds should be fired with the pause necessary for accurate observation of the practice; subsequently the battery commander must see to the correction of the laying and timing; the fire is then continued at a rate suitable to the position of affairs in the engagement.

As regards the selection of the object to be fired at, continuation of fire, and remaining immovable in the same position, the rules which apply to field artillery in general, are equally applicable to mountain guns; only it should be repeated that an advance of 150 to 250 yards has no satisfactory influence on the effect of the fire; consequently such short movements should be avoided.

(3) On the defensive, the battery commander should select as a position for his guns a spot from which all communications open to an enemy can be well commanded by the fire of the battery; he should endeavour at the same time to avail himself of every existing natural cover, or, when time admits, to get his battery under cover artificially; the distances of remarkable points of the ground in front—particularly of such parts as are calculated to delay the march of an enemy through difficulties of the ground—are measured by pacing. When the ground is favourable and permits of accurate observation of practice, and when the enemy is formed in large detachments, fire with common shell may be opened at 2000 or even 2500 yards, on the defensive.

When the enemy advances to a distance of from 850 to 1100 yards, shrapnel shells should be fired against columns; against detachments of small depth common shells should be fired at a high or low angle, according to circumstances. The rate of fire should correspond with the range, but under 250 yards an enemy should be plied with case shot as fast as possible. If our own troops retreat, the battery should be brought back to a position several hundred yards to the rear: that position should be particularly selected as one admitting of being long held and of a continuous fire. In such changes of position, the question as to whether the guns should be laden on the mules or not, must be decided by the style of engagement and the nature of the ground; generally speaking, the guns should be taken back by hand.

(4) In mountain warfare, engagements take place chiefly in and about defiles, and about heights.

The tactical importance of a defile depends on the strength of the troops who wish to pass it, on the style of engagement, on the nature of the ground in front or in rear of the defile, and on the dimensions of the defile.

In general the defence of a defile is undertaken from the rear: rarely from the front or from the inside.

A defensive position is taken up in front of a defile when in the act of retreating or when the nature of the ground is such as to present unusual advantages. In such case the guns should take post on the flank of the mouth of the defile, so as to be able to fire on the approaches and places of assembly of the enemy, and to ply the ground immediately in front with case shot. The guns, if possible, should be under artificial or natural cover, and should open fire as soon as the enemy comes within range. If our own troops are retreating, the battery should perseveringly continue firing as fast as possible until the troops have passed the defile; it should then retreat and take up a position some 800 yards in rear of the defile to prevent the enemy from debouching, at any rate to delay his opening fire as long as possible.

In the attack of an enemy in a defensive position *in front* of a defile the guns should be placed in position short of the most effective range, one part in the prolongation of the defile and the other to the flank, thus bringing the enemy under a cross-fire. The attacking guns direct their fire at the mouth of the defile, enfilading it; while those to the flank engage the guns posted in defence.

High-angle fire of common shells against the inside of the defile and against the enemy's guns, and low-angle fire for enfilading the defile and against the troops and guns in the open, will be found most suitable to the occasion.

The defence of a defile by guns *inside* it is not usually undertaken, for the retreat of the guns is generally involved in difficulty. Should however, such a position have been taken up, the guns should be placed behind obstacles to bar the way; they should continue their fire until the close approach of the enemy and the probability of losing the guns compel them to retreat.

The artillery of the assailant can only rarely be used inside the defile; but when so used, its duty is to cannonade the position of the enemy in the defile, as well as any bodies of troops or *abattis* visible. Fire at both low and high angles of common shell is that best calculated to destroy obstacles and to turn out troops from behind them. The ranges may vary very considerably according to the length and other conditions of the defile.

In defence *behind* a defile one part of the guns should be placed behind the mouth of the defile, at a distance short of the most effective range, enfilading the length of the defile and commanding the ground in front of the mouth; so as to impede the debouchment of the enemy's troops and guns, and to inflict on him the greatest possible loss at the moment of deployment and coming into action: the other part takes up a position to the flank and fire chiefly upon such of the enemy's troops and guns as succeed in gaining a position to the side of the mouth of the defile.

When a considerable part of the strength of the enemy has passed the defile, the defender may still turn the balance of the fight to his advantage by his superiority in numbers and by an energetic attack. The artillery should endeavour to shake the enemy by the liveliest fire against his front and flank and in conjunction with the infantry endeavour to drive him back into the defile; this, if successful, is always combined with very great loss to the enemy, and it may result in his total defeat.

The assailant who has to pass through the defile should bring up guns with the first detachment of closely formed troops to the front of the exit of the defile. Their duty is to fire at and drive back the guns and troops of the enemy and thus to facilitate the sortie of our own troops. To engage the enemy's artillery successfully the assailant should support the guns in action by others in positions on the flank.

In defending a height the artillery should in the first instance impede the enemy's advance by its fire; to this end it should place itself at the edge of the height, it should fire on the lines of access to the front and more particularly on those points where the advance of the enemy is delayed by difficulties of ground. The fire should increase in rapidity with the approach of the enemy and should reach its maximum as the enemy ascends the height. Before he reaches the summit, the battery should be withdrawn to a position in rear, whence he is to be received with an energetic fire of case shot: this ought to suffice either to throw him back or at any rate throw him into disorder and delay him. The capability of defence in a height depends on several conditions; when the slope of the height is gentle and where there is a plateau at the top, both are in favour of the position and effect of the guns: on the other hand, when the slope is precipitous, or when it is covered with trees or thick brushwood, the position is difficult to hold.

The attack of a height should be commenced by artillery firing on and endeavouring to silence such of the enemy's guns as command the roads or paths giving access to the height. When the troops storm and when they have established themselves on the height, the guns should follow so as to co-operate in a further advance or in maintaining the ground taken.

(5) The expenditure of ammunition should be regulated with constant reference to the momentary importance of the engagement and to the result to be attained; firing at ranges beyond the most effective range should only be allowed under very favourable circumstances; these rules are more particularly applicable to mountain batteries, as a fresh supply of ammunition from the park in rear generally involves greater difficulties and loss of time with mountain than it does with field-batteries.

NOTICES.

1. A limited number of copies of a paper by Colonel H. H. Maxwell, R.A., "Ballistics," applied to the M.L. Rifled 9-pr. Bronze Gun of 8 cwt., have been published, and can be obtained by members gratis, on application to the Secretary.

2. The Committee have decided that books sold at the R.A. Institution, at reduced rates, such as the "Handbook for Field Service," &c., can be obtained by members only, for their own use, or for presentation. This does not apply to books obtained for the use of N.C. Officers of the Regiment.

3. Unbound copies of the "Records of the R.M. Academy," from 1741 to 1840, can be obtained at the Institution by members. Price 5s.

CENTRAL ASIA,

AND

OUR MILITARY POSITION ON THE NORTH-WEST FRONTIER OF INDIA.

A PAPER READ AT

THE R.A. INSTITUTION, WOOLWICH,

BY COLONEL JOHN ADYE, C.B. R.A.,

JANUARY 20, 1870.

The subject which I am desirous of bringing to your notice, is one which generally goes by the somewhat wide and rather indefinite name of the "Central Asian" question.

It is one regarding which much has lately been written, and yet one which is, I believe, not generally well understood. It excites interest because its solution affects our future in India, and yet—owing to the inaccessibility of some of the regions concerned—the real condition of matters can with difficulty be ascertained. In the statements I am about to make, I do not pretend to possess any special or exclusive means of knowledge, and time only permits me to give a rapid outline; but having studied the subject for some time, I am in hopes that what I am about to say may be of some slight interest to my brother officers and others now present.

I propose to divide my subject as follows:—

First,—To say a few words as to our present military and political position on the north-west frontier of India.

Secondly,—To give a concise account of the gradual advance of Russia southwards, with a sketch of the countries intervening between us.

Thirdly,—To offer suggestions as to what should be our line of policy towards our neighbours.

Until our arrival in the East, all the great invasions of India for centuries past had been made from the north-west; that is, from Central Asia. The original Hindoo races of India have been periodically flooded, as it were, by successive Mahomedan waves, which penetrated throughout the Peninsula.

When we arrived in India, the Mahomedan power was in its decline.

I have not time, nor indeed is it necessary for me to relate how, beginning with small trading factories on the coast, we gradually rolled back the tide of Mussulman invasion; how we gradually raised armies, composed in great part of the natives of the country; how we advanced, and, ever conquering, saw kingdom and principality fall, one after another, under our sway, until at length our frontier line was pushed forward as far as the banks of the Sutlej. Behind us we had left the descendant of the Moguls in titular sovereignty at Delhi, and before us stood Runjut Sing, the Lion of the Punjab. This was our position thirty years ago.

It was in the year 1839, as you are aware, that in concert with our then allies the Siekhs, we advanced with an army across the Indus, and threading the Bolam Pass, finally reached Cabul; and it was in 1841 that that terrible disaster occurred in which we lost that army, and for the time were driven out of Afghanistan. It is not necessary that I should recount the history of those days; I merely recall them to your memory as the opening scene in the Central Asian drama.

In 1849, after the great battles of Chillianwallah and Goojerat, the Punjab fell into our possession, we crossed the Indus, and our frontier was then advanced to its present boundary, namely to the foot of the Afghan Mountains.

In speaking of the Punjab, it is often alluded to as the country of the Siekhs, as if the whole of it were inhabited by people of that race. This, however, is by no means the case. All about Lahore, Umritsur, and the lower parts of the Punjab, the great majority are of the Siekh faith, but towards the north it is not so, and the inhabitants are for the most part Punjabee Mussulmen; and once across the Indus, the men of the tribes in the plains, in language, religion, race, and character, are Afghans—that is, bigoted Mahomedans.

I have said these few words on the religious aspect of the case, because it is one which necessarily affects our policy; and you will observe that however sharply defined is our north-west frontier in a geographical point of view, there is no such distinction between the inhabitants on either side of the border.

After the conquest of the Punjab by Lord Gough in 1849, we of course inherited and adopted the former frontier line of the Siekhs—a somewhat uncertain and devious one, running for hundreds of miles along the foot of the Afghan Mountains (the Soliman range). It extends from Scinde to Cashmere, and speaking roughly may be 800 miles long. We have crossed the Indus, and thus hold a long, narrow strip of flat country between it and the base of the hills.

Our line is guarded by a series of detached forts and stations, the chief of which from south to north are Dera Ghazee Khan, Dera Ishmael Khan, Bunnoo, Kohat, Peshawur, Hoti Mundan, and Abbotabad in Hazara. None of these are strongly fortified, and the distances between them are considerable—say forty or fifty miles or more. We have minor fortified posts all along, at the foot of the mountains, ten or twenty miles apart. The military arrangements are peculiar; with the exception of Peshawur, all the other posts are held by a total force of about 10,000 men of the three arms, the regiments and batteries being composed entirely of men raised on the spot—that is, of Siekhs, Punjabee Mussulmen, and a certain number from the independent hill tribes in our front, the whole commanded by English officers. This force is under the command of a general whose head-quarters are usually at Abbotabad, and who reports to the Lieutenant-Governor of the Punjab at Lahore; that is, he is independent of the Commander-in-Chief.

The key of the position, Peshawur, standing in front of the mouth of the celebrated Kyber Pass, and commanding the main road from Cabul, is however held by a considerable force of the regular army, under a general officer who reports to the Commander-in-Chief.

I have said that the military arrangements are peculiar, and I venture to think you will agree with me in considering them in some respects defective —that is to say, our long line is guarded by troops under two different generals independent of each other, and there are no reserves of any importance at hand; consequently if war threatens at any point, it becomes necessary to weaken others, at a critical moment.

To hold a long, exposed frontier by alien troops raised on the spot, and to the almost total exclusion of English soldiers, is a bold and possibly a dangerous policy; but to increase the risk by a complex division of military authority is a violation of all commonly received maxims of war. I have not adverted to the lower part of the frontier in Scinde; but here again is a third general guarding the Bolam, and other local levies, and they are under the Government of Bombay.

From what I have said, you will observe that we hold a long, narrow strip of country Trans-Indus. We stand at the foot of a line of mountains full of fierce hostile tribes, and with a great river at our backs. We are perpetually at war at various parts of the line, and during the last twenty years as many expeditions have entered the Afghan country, to punish the border tribes for outrages on our territory. One of the chief campaigns was in 1863, against the Sitana fanatics to the north of Attock.

I am desirous that you should understand the nature of our military position to the north-west, because it has an important bearing on our external policy.

The chief countries of Central Asia, of which I propose to say a few words before entering on the advance of Russia, are:—

1. Cashmere and Ladak to the south-east.
2. Chinese Turkestan to the north-east.
3. Afghanistan to the south-west.
4. The three khanates or principalities of Khiva, Bokhara, and Kokan in the north-west.

Cashmere and Ladak—provinces composed almost entirely of great chains of mountains, sheltering deep and beautiful valleys—though partially under our protection and included within our border, are in reality governed by the ruler of Cashmere, who maintains his own troops, and carries on his own little wars without our help. He has of late been engaged in warfare with the tribes to the north, in the valley of Gilgit, a very difficult and little-known country lying under the southern slopes of the Hindoo Koosh.

There is said to be a road up this valley and over the Pamir Steppe to Kokan, but it must be a mere mountain track and of little use for commerce.

I may mention that the Pamir Steppe is supposed to be the highest table land in the world, and it is sometimes called "the roof of the world." It is said to be 15,000 feet above the sea, and to be studded with lakes; but it is not yet thoroughly known. I believe that an English gentleman is at this time endeavouring to make his way there by the road I have named.*

We have a British representative in Cashmere, but no troops, and within the last few years we have also had an agent at Leh, the principal town of the outlying province of Ladak.

Our chief object at present is to encourage trade from Chinese Turkestan, and to enter into political intercourse with the ruler of that country, who has lately risen to power.

The people of Cashmere and Ladak are for the most part poor, quiet, and inoffensive.

There are one or two routes from Ladak to Turkestan, but they lead over gigantic mountain chains, the lowest pass being 18,000 feet above the sea, and for many days of the journey there is neither food nor forage to be had. Consequently the intercourse with China and Thibet is difficult, owing to natural obstacles, and our attempts at trade are almost strangled by the heavy duties in transit imposed by the ruler of Cashmere.

Chinese Turkestan for many years past, and indeed until quite lately, has been to us a sealed book. This great south-western province of China, lying between the Kuen Luen Mountains to the south, the Tian Shan range to the north, and the elevated Pamir Steppe closing it to the west, contains several large and important commercial cities—namely Koten Yarkund, Kashgar, Aksu, and others. The people are for the most part Turkish in nationality and Mahomedans in religion, but owing to the distracted state of the country, to the cruelty and fanaticism of the rulers and the people, it has been rendered quite impossible of approach.

Within the last few years, however, a great Mahomedan ruler has arisen called Yakoob Kushbegi, who has rendered himself independent of the Chinese, and who—somewhat perplexed perhaps by the advance of Russia from the north, their outposts now looking down on him from the crests of the Tian Shan—has shown a disposition to cultivate our friendship and to promote trade.

Two English gentlemen indeed, within the last year or two, have visited Yarkund, and have returned in safety—the first for many years—and there is therefore a hope that ere long our political influence, our knowledge of the country, and our trade, may increase.

It is supposed by some that the tide of Russian advance may develope itself in this quarter, and that their troops may thus appear on the flank, as it were, of Cashmere; but considering the great difficulties of the mountain ranges, any danger to India in this quarter seems out of the question, even supposing ideas of aggression were entertained.

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* The latest account, taken from the "Times" of Jan. 3rd, 1870, says:—"Mr Hayward, now in Cashmere, has set out to explore the great Pamir Steppe through the Maharajah's frontier country of Gilgit. Unfortunately the Maharajah's officials do not like Englishmen to penetrate into the land, and, while openly proposing assistance, represent the danger as excessive. Still, Mr Hayward writes:—'I feel bound to try my best, but the prospects of being able to penetrate to the Pamir seem very little. I still believe that I shall eventually accomplish my object, but it may take months—nay years, to do so.'"

Afghanistan, the country which lies just beyond our north-west border, has been so often described, and is so well known as compared to the other regions of Central Asia, that I need hardly do more than allude to a few of its general outlines.

It is a country for the most part of narrow sheltered valleys, lying between the great mountain spurs, which radiate from the Hindoo Koosh, and which traverse and divide the land from end to end, one of the principal chains, the "Soliman," forming its boundary with our dominions. It is a rugged and comparatively a poor country, with few good roads, and therefore ill adapted for military movements on a large scale.

The Afghans are a brave, hardy, and fierce people, fond of fighting for fighting's sake; incessantly quarrelling amongst themselves, but ever ready to combine against others. They are fanatical, revengeful, and cruel, and they have suffered long under that curse of wretched government and distracted rule, which seems now to be one of the distinguishing features of all the countries of Central Asia. The Afghans are an independent nation, but all along our border there are a number of tribes varying in strength, who, though Afghans in race, religion, feeling, and language, are professedly independent of each other and of the chief ruler at Cabul.

Although Afghanistan is so shut off from us by a screen of mountains, still there is a certain amount of trade carried on between us; the two chief roads being by the Bolam and Kyber Passes. There is however not much reciprocity of feeling on their part; for although we allow them to travel freely in our country and to trade in our bazaars, no Englishman dare venture alone even to the foot of their mountains, much less enter their country.

The kingdom generally consists of a number of rather loosely knit states, most of them lying to the southward of the Hindoo Koosh range. The chief towns are Cabul, Ghuznee, Candahar, and Herat. When the ruler is a man of strong character, then the country remains tolerably united and quiet; otherwise it soon falls into anarchy and confusion. In our European sense of the word, it can hardly be called a kingdom; like many other countries in the East it is ruled by might rather than by right.

The great old chief Dost Mahomed died in 1863, and since then the country has gone through the miseries of a war of succession, the sons fighting over the father's patrimony. Shere Ali Khan seems now tolerably firmly established at Cabul, and no doubt the favour and support lately shewn him by the Viceroy, Lord Mayo, at Umballah, have contributed to this result. I will revert to this topic in speaking of our general policy.

The three great independent khanates or principalities, Khiva, Bokhara, and Kokan, which together form the north-western division of Central Asia —once the seat of civilisation and the arts—are now, and have been for a long period of time, cursed by all the miseries of wretched government, and their fair provinces have been desolated and ruined by the hands of cruel men. Many portions of this vast country are fertile and beautiful, and are well adapted in every respect for the circumstances of peaceful and prosperous existence; and in spite of tyranny and misgovernment, parts of it (especially the valleys which lie about the upper parts of the rivers Oxus and Jaxartes), are cultivated and comparatively prosperous—the inhabitants of the hill sides given to pastoral pursuits, and those of the valleys engaged in agriculture and commerce. There are many large, flourishing cities in the upper parts of Bokhara and Kokan.

The other parts of the country towards the Caspian and the Aral, vary much in their character, and large tracts consist of arid, almost pathless deserts, sparsely inhabited by wild, nomadic Turcoman tribes.

These three great principalities are independent of each other, and are often at war; but each and all of them are now beginning to feel the influence of that great wave of Russian invasion which, slowly but surely, is approaching from the north, and which as surely will ere long absorb them into one common kingdom. Whatever changes the advance of Russia may make, and however much or little it may ultimately affect our position in the East, no one can regret that an end should be put to these governments, which for a long period of time, by their cruel tyranny, fanaticism, and depravity, have been a curse to the people placed under their rule.

For many years past the whole country has been so unsafe for travellers, that there is hardly an European alive who has successfully passed through it, and consequently it has been impossible to ascertain with any exactness the real condition of affairs in the three kingdoms.

In a military point of view, neither Khiva, Bokhara, or Kokan are very powerful. Bokhara is the most so, and is said to have an army of 40,000 men and some batteries of artillery.

The chief obstacles therefore to the Russian advance, arise from the want of adequate roads, and from the difficulties of obtaining supplies of food and water in traversing the wide sandy deserts, which extend over a great portion of the country. The distances also are great, so that it is easy to understand that any forward movement can only be made by small, detached bodies, which are liable to be cut off, or to be at all events detained by the desultory attacks of the wild nomadic tribes of the desert.

The Advance of Russia.

The old southern boundary of Russia in Central Asia, extended from the Ural, north of the Caspian by Orenburg and Orsk, and then across to the old Mongolian city of Semipalatinsk, and was guarded by a cordon of forts and Cossack outposts. This line was no less than 2000 miles in length, and "abutted on the great Kirghis Steppe along its northern skirts, and to a certain extent controlled the tribes pasturing in the vicinity, but by no means established the hold of Russia on that pathless, and for the most part, lifeless waste."

There is an admirable article in the "Quarterly Review" of October, 1865, written I believe by a very high authority on the subject, which describes the position of Russia about thirty years ago, and from which I will quote one or two extracts, before I proceed to give an account of her more recent conquests. It says:—

> "A great Tartar Empire, which should unite Siberia with the fertile valleys of the Oxus and Jaxartes, had been imagined by the Russian Czars as early as the 16th century, and would probably have been realized, either by Peter the Great or Catherine, but for the intervening wilderness of the Kirghis-Kazzacks. Extending for 2000 miles from west to east, and for 1000 miles from north to south, and

impassable, except to a well-appointed caravan at certain seasons and along particular tracks, this vast steppe seemed to have been placed by nature as a buffer between the power of civilized Europe, and the weakness and barbarism of Central Asia."

Then, speaking of a later date, the article in the "Quarterly" says:—

"It was in 1847, contemporaneously with our final conquest of the Punjab, that the curtain rose on the agressive Russian drama in Central Asia, which is not yet played out. Russia had enjoyed the nominal dependency of the Kirghis Kazzacks of the little horde who inhabited the western division of the great steppe since 1730; but, except in the immediate vicinity of the Orenburg line, she had little real control over the tribes. In 1847–48, however, she erected three important fortresses in the very heart of the steppe." [Two of them are shewn on the map.] "These important works—the only permanent constructions which had hitherto been attempted south of the line—enabled Russia for the first time to dominate the western portion of the steppe, and to command the great routes of communication with Central Asia. But the steppe forts were, after all, a mere means to an end; they formed the connecting link between the old frontier of the empire and the long coveted line of the Jaxartes, and simultaneously with their erection arose Fort Aralsk, near the *embouchure* of the river."

In the meantime, in 1839, the Russians had sent an expedition from Orenburg against Khiva under Perofski; but which, having suffered from hunger, thirst, and disease in the desert of Bar-sak, north-west of the Aral, was forced to a disastrous retreat. This was about the same time that we, in like manner, were retreating from Afghanistan.

The Russians having crossed the great steppe, and having established themselves on the Jaxartes, at once transported materials for two steamers for the navigation of the river. It was from this time that they came permanently into contact with the three great khanates of Central Asia.

Turning for a moment to the Caspian, it must be mentioned that by means of steamers down the Volga and in the Caspian, she has now gained the complete mastery on that great inland sea, and has built the fort of Mongishlak on the eastern coast, and of late years has also established a fortified station at Ashourada, in the complete south, near Astrabad.

Once across the desert and secure upon the Jaxartes, the progress of Russia southwards has been comparatively easy. Each year has seen a step in advance, forts rising up in succession along the banks of the river. In 1853 the Russians had ascended the river as far as Ak Metchet, and built a fort there, now called "Perofski." The Crimean war checked their progress for a few years, but latterly it has been rapid. In the year 1864 Aulietta and Chemkend fell, and Tashkend—a flourishing city of considerable trade—the following year.

Admiral Boutakoff, the distinguished officer who commanded the "Vladimir" at the siege of Sebastopol, is said to have navigated the Jaxartes for 1000 miles in 1863.

Thus in a few years Russia had reached almost to the heart of Kokan, and was in close proximity to Bokhara.

On the eastern border of the great Kirghis Steppe her progress has been equally decisive, and the country being generally more fertile, the difficulties have been less. Her troops, leaving Semipalatinsk, marched southwards towards the Balkash Lake, and in 1854 established a military settlement and built Fort Vernoe, north of the lake Issy-Kul. This is an important place, being at the junction of the cross roads from Semipalatinsk to Kashgar, and from Kokan to Ili or Kuldja.

Then, in order more fully to secure their position, they turned westwards, and capturing several Kokan forts in succession, Aulietta and Turkistan being among the number, they thus joined their eastern to their western line of advance. In his circular detailing these events, Prince Gortchakoff, in 1865, said that "the purpose of last year's campaign was that the fortified lines of the frontier—the one running from China to Lake Issy-Kul, the other stretching from the Aral along the Sir Daria—should be united by fortified points, so that all our posts should be in a position for mutual support."

Although in all these movements the Russians had encountered opposition, and had fought numerous battles, still none of them were on any great scale. The numbers engaged were comparatively few, and the losses on the Russian side have always been trifling.

Indeed, from the causes already mentioned—that is, want of roads and of supplies—the advances of Russia have always been made with small detachments, step by step, fortifying posts as they went. On the other hand, it is evident that none of the powers of Central Asia have the means of bringing very large, disciplined, well-armed masses into the field.

Russia, in 1864, had thus not only left the desert behind, but found herself in possession of several large and flourishing cities, in a fruitful, well cultivated country; a country in which corn and cotton are grown in considerable quantities, and in which mines of the precious metals and also of coal exist. Kokan is at her mercy, and Bokhara hardly less so; and although the distances are great, the communications to the rear are comparatively safe and easy. Envoys from Kokan visited India in 1860 and in 1864, to ask for support, but were not successful. Tashkend had fallen in 1865, and Khojend was captured the following year. The battle in May, 1866, which preceded the fall of that city, is the most considerable that has occurred, and is called the battle of "Irdjar." The Emir of Bokhara commanded in person on the occasion, and is said to have had 21 pieces of artillery, 5000 regular infantry, and 35,000 auxiliary Kirghis, against 14 companies of infantry, 5 squadrons of cavalry, and 20 guns on the part of Russia. The fighting, however, must have been meagre, and the battle more a flight and massacre than anything else; the Russian loss being given as only 12 wounded, whilst the Emir left 1000 dead bodies on the field. He also lost his camp equipage and baggage, and returned to Samarcand with only 2000 horse and 2 guns.

Khojend stands on the left bank of the Jaxartes, and is surrounded by a double line of thick high walls, said to be seven miles in circuit. It was taken by escalade at the end of May, after considerable resistance.

In 1868 the Russians took another decisive step; and, after another battle, the ancient and important city of Samarcand fell into their possession.

Thus the heart of Bokhara has been reached, as well as that of Kokan, and although in neither case has the capital yet fallen, both may probably do so ere long. I may mention that in the winter of 1866, an envoy from Bokhara came to Calcutta to ask for assistance from England, but his mission was unsuccessful.

The advanced posts of Russia on the eastern side are now pushed forward to the crests of the Tian Shan range, and are looking down upon Chinese Tartary, as I have already explained, and the Russians are now negociating for a trading factory at Kashgar.

With regard to Khiva we know and hear less than of the two other khanates, nor does Russia appear as yet to have touched that principality in any vital degree. She is believed, however, to be forcing her way up the great river Oxus; and the latest accounts state that an expedition is about to leave the Bay of Balkan, on the eastern shores of the Caspian, and to establish a new route due east to the Oxus. The object is stated to be, to facilitate trade with Bokhara; and no doubt, if successful, it will be far shorter than the present lines of communication; but, on the other hand, the difficulties and dangers of crossing a great arid desert, deficient in food and water, and thinly inhabited by hostile wandering tribes, must be very great. If it can be accomplished, it will completely take Khiva in flank, and there is no power in that principality which will enable it to hold out for any length of time.

I think that what I have said will have served to explain the great progress which Russia has made southwards, more especially within the last few years, and the comparative ease with which her advances have been made.

Before proceeding further, may I ask your attention for a moment to the map, and to what may be called the geographical approximation of England and Russia in the East; and here again I will quote a sentence from that excellent article in the "Quarterly:"—

> "While England, in taking possession of the line of the Indus from the seaboard to Peshawur, has penetrated on one side nearly 1000 miles into the 'debatable land' of former days; Russia, on the other side, by incorporating the great Kirghis Steppe into the empire, and substituting the Jaxartes for the Siberian line of forts as her southern frontier, has made a stride of corresponding dimensions to meet us; so that instead of the two empires being divided by half the continent of Asia as of old, there is now intervening between their political frontiers a mere narrow slip of territory, a few hundred miles across, occupied either by tribes torn by internecine war, or nationalities in the last stage of decrepitude, and traversed by military routes in all directions."

The shortest distance between us, as the crow flies, may be about 400 miles.

Russia has now several roads by which she may advance in a southerly direction. On the eastern side there are two passes, one near the Pamir Steppe and another above Aksu, by which she can descend into the plains of Chinese Tartary and so approach Cashmere; but the difficulties of any further progress towards India in this direction, appear almost insuperable, owing to the obstacles presented by the Himalayan ranges.

There is also a track over the Pamir Steppe from Kokan, which, as it descends the southern slopes, bifurcates—one branch as I have mentioned running into Cashmere through the Gilgit Valley, the other leading westward to Cabul.

These, however, I imagine are quite unfit for the march of any considerable force.

From Samarcand and Bokhara there is a road across the Oxus to Balkh in Afghanistan, and by Bamian over the passes of the Hindoo Koosh to Cabul. A battery of Bengal Horse Artillery succeeded in crossing the range by this road when in pursuit of Dost Mahomed northwards in 1840, but the difficulties are almost insurmountable. There is, however, another and a far more feasible route for a Russian advance towards India than any of those I have yet alluded to—namely by the Caspian to Ashourada, Astrabad, and so on, *viâ* Meshed, to Herat and Candahar. The distances doubtless are considerable (forty marches from Astrabad to Herat), the difficulties are great, and the country has been partially devastated by marauding tribes; nevertheless, as it is fertile and populous, it is in every respect a far more easy road than the others, besides which an advance in that direction would turn the flank of the Hindoo Koosh. A railway is said to be projected from Astrabad to Herat. Herat standing on this road, on the borders of Afghanistan, occupies a position of great strategical importance, and has been a constant source of strife between the Persians and the Afghans. There are indeed many English officers, who looking upon the Hindoo Koosh as the line of our natural frontier, advocate the immediate advance of a British force and the occupation of Herat.

I have now endeavoured to give you a sketch of the gradual progress and of the present position of Russia in Central Asia; I am aware that it is but a sketch, but time will admit of no more. You will have observed that her policy is a steadfast, unchanging one, and is pursued year by year, in spite of difficulties and occasional delays. She has crossed great deserts, and by means of inland seas and great rivers has succeeded in establishing her communications, and in penetrating to the heart of the three great principalities, and to their most fruitful provinces. She is now busily engaged in strengthening her position, developing her commerce, and preparing for fresh enterprises.

It is also evident that no great military power exists which is able to check her progress. Bokhara, Khiva, and Kokan have not even been able to take advantage of the natural difficulties of the country to offer more than a momentary opposition. Chinese Turkestan is also in too unsettled a state to hold out against a powerful attack. Persia, though more formidable, is perhaps more likely to prove an ally than a vigorous enemy. Afghanistan, with its rugged mountains, its brave and warlike people, alone remains to stem the tide of advance.

There are many, both in England and in India, who regard the southward march of Russia with considerable alarm, as affecting our position in the East. This indeed is no new feeling. Our advance to Cabul thirty years ago was in a measure caused by an exaggerated fear of Russia even in those days, and I have shown you how great her progress has been since that time. There are others again who take quite the opposite view, and who maintain that the conquest of Central Asia by Russia will contribute to the general welfare of the people concerned, and that danger to India is almost impossible, owing to the distances still remaining to be traversed, and to the difficulties which under such circumstances must arise in the movements of large bodies towards our frontiers. In short they look upon any collision between ourselves and Russia in the East as almost a delusion.

I am not of those who regard the question from an alarmist point of view, and I can well understand that the absorption of those miserable principalities by a great Christian civilized power, may be a material blessing to the people; but looking at the vast progress Russia has made, especially of late years, and anticipating that ere long her outposts will assuredly arrive at the northern slopes of the Hindoo Koosh, it does appear to me a matter of considerable importance to us, that our Indian Empire should thus be brought into comparative proximity with another great military power, instead of as hitherto, our being surrounded by troublesome but weak Asiatic tribes.

It may not be a matter for alarm, but it can hardly be one for indifference.

As regards the supposed impossibility of Russia's further advance, owing to distances and natural obstacles, no doubt there is much to be said; but judging by our own experience, and looking back at our own work during the last century, it does not appear that any such considerations have checked our progress, which has been attended with far more difficulties than any Russia is now likely to encounter.

As Sir John Malcolm said, in his "Political History of India:"—

> "The great empire which England has established in the East will be the theme of wonder to succeeding ages. That a small island in the Atlantic should have conquered and held the vast continent of India as a subject province, is in itself a fact which can never be stated without exciting astonishment. But the surprise will be increased when it is added that this great conquest was made, not by the collective force of the nation, but by a company of merchants who, originally vested with a charter of exclusive commerce * * * actually found themselves called upon to act in the character of sovereigns over extended kingdoms, before they had ceased to be the mercantile directors of petty factories."

I have quoted this passage from the writings of a celebrated man to remind you of the great work we have accomplished in the East.

We have not only sailed for thousands of miles over distant seas, but beginning with small factories on the coast, have marched 1600 miles from Calcutta to Peshawur, and overturning kingdom after kingdom—many of them of considerable military power—we have at length reached the confines of Central Asia. It is surely not for us then to speak of impossibilities. Considering it then as a moral certainty that Russia will ere many years reach the northern slopes of the Hindoo Koosh, the question naturally arises as to what our general line of policy should be?

In considering our north-west policy, three courses appear to be open to us.

The first is absolute neutrality, or what is called "masterly inactivity."

The second is to advance to the conquest of the greater portion of Afghanistan, and to take up the line of the Hindoo Koosh, with Herat as the extreme point on our left flank.

The third is to conciliate, and if necessary to subsidize the Afghans; to establish if possible a strong government in that country, and thus to convert them into faithful allies, and induce them to hold their mountain ranges as a barrier against all comers.

As regards the first—neutrality—were we in possession of the mountains which fringe our frontier, or were our neighbours a quiet, inoffensive, powerless race, or were the mountains inaccessible, and their topmost ridges crested with the eternal snows, as are those of the higher Himalayan ranges; and further, were no great power approaching, we might no doubt remain within our own borders, and be content to disregard the outer world, and to guard our line by a thin cordon of forts and pickets. In the north-eastern frontier of India these characteristics with some exceptions do exist, and consequently our policy there is rendered comparatively simple. But on the north-west, as I have endeavoured to explain, our position is altogether different. We stand at the very foot of a long range of mountains held by a fierce people ever ready to attack, and who, though nominally independent, are one in race, religion, and feelings with the Afghans in their rear. It is true that there are but two main passes, the Kyber and the Bolam, by which armies can be brought into India, but there are several minor intermediate ones, available as auxiliary routes, and now used for purposes of trade; and all along the border the tribes find no difficulty in descending at will and invading our frontier. The country is rugged but not inaccessible.

Afghanistan itself, though comparatively a poor country, still contains numerous fruitful valleys, where troops could be assembled and supplies obtained; so that a great power in alliance with the Afghans, and if in possession of Herat and Candahar, could assemble its forces behind the screen of mountains, and *debouche* when ready in our plains. It seems to me, therefore, that with our long, thinly-guarded frontier, with brave enemies in our front, with our backs to a great river, and with a great power looming in the distance, we are by no means in a position to fold our arms and to proclaim a policy of indifference. We live next door to very unruly neighbours, who have the vantage ground, and we must at least exercise police vigilance, even if we choose to ignore the higher functions of active diplomacy.

It is sometimes urged that in case of attack we might fall back across the Indus, but to do so would involve a loss of territory as well as of prestige. Not only that, but with only one bank of the river in our possession, we should at once lose the use of it as a means of lateral communication, and it is the only one we have at present. It is also sometimes urged that if we ever are invaded in force, we should let our enemies come on, and then fight them in the open plains. The commander of a fortress, however, would hardly be held justified were he to abandon his ramparts and to wait for his foes in the centre of his citadel. If we are to fight a great battle in the plains of India, it will probably, I think, be nearly the last, but certainly not the first of the campaign.

Masterly inactivity is therefore out of the question.

The second line of policy, and one sometimes advocated, is that of the sword; namely that we should advance at once, boldly, to the conquest of Afghanistan, seize Candahar and Herat, and thus adopt the line of the Hindoo Koosh as a secure barrier.

This is certainly a simple and an intelligible course of action; but judging from past experience it would involve us in a costly, dangerous war, in a poor, rugged, inhospitable country, far away from our resources, and would bring us into collision with a race of fierce, implacable mountaineers.

It would be might without right. Therefore, although I do not say that the time may not come when it may be necessary, in alliance with the Afghans, to push forward troops even to Herat, that period has certainly not arrived yet, and we should only rouse enmities and prejudice our position, by such high-handed precipitate military tactics.

The third and last course, namely that of conciliation, I must confess is the one that from every point of view seems to me the most advisable. All that I have already said will I think prove that Afghanistan, with its rugged mountains and its brave people, will ere long alone remain between us and the dominions of Russia, and that any advance on India in force is only feasible through Afghanistan.

I have attempted to prove that neutrality is impossible, and that conquest on our part would in a military sense be a blunder, and in a political one a crime.

The greater part of Afghanistan lies among the southerly spurs of the great Hindoo Koosh, and therefore the very geographical position of its provinces points out that its people are indeed our natural allies—that is, they are in possession of our natural frontier of mountains.

It therefore becomes essential to us that Russia should not gain possession of the very gates of our empire. Indeed I do not see that we could possibly stand idle, if Herat and Candahar were to be threatened. We must surely advance and anticipate any such attempt.

Surely then, if instead of conquest we turn to conciliation, whilst there is yet time, may we not hope that, not only shall we succeed in gaining our true boundary, but shall induce the brave and warlike Afghans to be our very frontier defenders. This appears to me to be the true key to our frontier policy. But then to carry it out successfully we must not hold our neighbours at arm's length as we have done for years; we must not treat this brave but jealous people in a high-handed domineering manner as we did in 1839 and have often done since. We must try and learn to look at the question from an Afghan point of view; we must remember that in conquering India we have invaded a great country which for centuries past they have looked on as their natural field for enterprise; that our flag now flies at the very foot of their native mountains; and poor, hungry, and ignorant Asiatics as they are, it is hardly to be wondered at that they should receive our overtures with suspicion, and view our presence with dislike. That arbitrary red frontier line not only cuts them off from the fertile plains, but interferes with landed claims and tenures which, though ill defined, still deserve consideration. As we are strong then, so must we be forbearing. It is very possible that in the frontier disturbances of the last twenty years, they have often been in the wrong, but the hereditary instincts of centuries are not to be obliterated in a day, and their ideas of property and of right and wrong are probably more elastic than our own. We must not, therefore, judge these Afghans by too rigid an English standard. With all their faults they are brave, hospitable, and courteous, and are possessed of a great love for their religion, their women, and their country, and they thus possess many of those virtues which we esteem so highly among ourselves.

I really hope, and I almost feel, that you will agree with me to a great extent in my views of conciliation. Surely humanity and kindness are good starting points in agreements with our neighbours!

It is, however, often said that these people are fickle and faithless, and that subsidies and conciliation, though good in theory, will fail in practice. I am of course aware that there are considerable difficulties to be encountered, nor do I anticipate that our friendly overtures will produce any immediate striking result; but turning for a few moments to the history of our dealings with the Afghans, of recent years, it will be found that the conciliatory friendly policy, on the only occasion when it has been fairly tried, at once bore good fruit, and that too on a very critical and momentous occasion, and in a way we little expected. I will quote the instance.

In the year 1856 Dost Mahomed was the ruler of Afghanistan, and being anxious for obvious reasons that the Persians, who had then captured Herat, should be driven out of it, we entered into a treaty with Dost Mahomed accordingly. The following is the first and chief article of the treaty:—

> "Whereas the Shah of Persia, contrary to his engagement with the British Government, has taken possession of Herat, and has manifested an intention to interfere in the present possessions of Ameer Dost Mahomed Khan, and there is now war between the British and Persian Governments; therefore the Honourable East India Company, to aid Ameer Dost Mahomed Khan to defend and maintain his present possessions in Balk, Cabul, and Candahar against Persia, hereby agrees out of friendship to give the said Ameer one lac of Company's rupees (£10,000) monthly during the war with Persia."

The other conditions of the treaty were that the Ameer should maintain a certain force under arms, and should receive an English officer. He was also presented with 4000 muskets.

This treaty was signed by the present Lord Lawrence, who was then Chief Commissioner of the Punjab, on the 26th of January, 1857 (mark the date), and one result was that the Persians were driven out of Herat as we wished; but another, and quite an unexpected result may, I think, be at all events in part attributed to our timely conciliation.

In May, 1857, only four months after the treaty was signed, the great mutiny broke out, and the Punjab, like all the rest of India, was in extreme peril; but although it is believed that Dost Mahomed was urged to attack us, and although it is said that thousands of Afghan horsemen were eager to be let loose across the border, it is nevertheless a fact that this great old chief, who had little cause to love us for our treatment of him in former years, did not draw the sword nor move a man against us in the hour of our dire extremity. It is of course impossible to say how far our kind reception of him, and our liberality towards him in the previous January, may have led him to remain quiescent the following May, but at least it may be concluded that our treaty was made at a very opportune moment, and to my mind it is a pregnant proof that the Afghans are not so faithless as is often asserted.

Dost Mahomed died in the summer of 1863. The son of his selection, the Ameer Shere Ali Khan, now rules in Cabul, after a long civil war, and at the beginning of last year come down as far as Umballa to visit Lord Mayo, the present Viceroy of India. He was royally entertained, and has also been granted a subsidy of equal amount to that temporarily given to his father.

Although the mere grant of a subsidy is not the highest form of diplomacy, and although time and patience are required to prove the sincerity and disinterested nature of our friendship, still it does appear to me that the course we are now pursuing is a far-seeing and a statesmanlike one, and if we can succeed in establishing a strong Government in Afghanistan, and in proving to the Afghans that *alliance* and not *conquest* is our motto, we shall have done a great deal to solve the difficulties of the Central Asian question.

As regards our present military position on the frontier, in my opinion we should hold the Trans-Indus districts with light troops, ready to move at the shortest notice, but should avoid permanent works or large magazines on such an exposed frontier. We should strengthen our position Cis-Indus, improve our lateral communications, and complete the railway from Lahore to Peshawur. We should of course rectify the defective military arrangements to which I have already alluded.

I have left myself but little time to advert to the southern part of our line of defence—namely, the Scinde frontier, where our troops hold a very important position, guarding the entrance to the Bolam, the easiest road to India from Central Asia. That celebrated artilleryman and diplomatist, the late General Jacob, who long held the command in Scinde, strongly advocated years ago that we should advance through the Bolam, and in alliance with the Khan of Khelat, hold Quetta, and then subsidize the Afghans; that we should thus not only hold the Bolam, but be on the flank, as it were, of the Kyber. General Jacob's distinguished successor, Sir Henry Green, who has honoured us with his company on this occasion, holds I believe precisely similar views, and has not long since again pressed them upon the Government of India.

As this is an Artillery Institution, and as the majority of my audience are of my own corps, and further as there are several distinguished officers present whose service has been chiefly passed in India, I wish before I close my remarks to call to your remembrance the names of a few of the artillery officers who have made themselves famous in the wars, and in the diplomacy of the period of which I have been speaking.

There was Eldred Pottinger, a young officer of the Bombay Artillery, who so gallantly assisted in the defence of Herat in 1838.

D'Arcy Todd, of the Bengal Artillery, who succeeded him in his political capacity at that important place.

General James Abbott, whose sufferings in his chivalrous mission to Khiva are so well known.

The late Sir Richmond Shakspear, who served with distinction in the first Afghan war, and who had the good fortune afterwards to liberate our captives.

General Sir Vincent Eyre, who also took part in the Afghan war, and who suffered a painful captivity, and who has both written and spoken so ably on Central Asian politics.

Then again the late General Jacob, of the Bombay Artillery, to whom I have already alluded—a distinguished soldier, diplomatist, and writer.

I may perhaps also be allowed to name Mr Kaye, the historian of the Afghan war, who was formerly in the artillery.

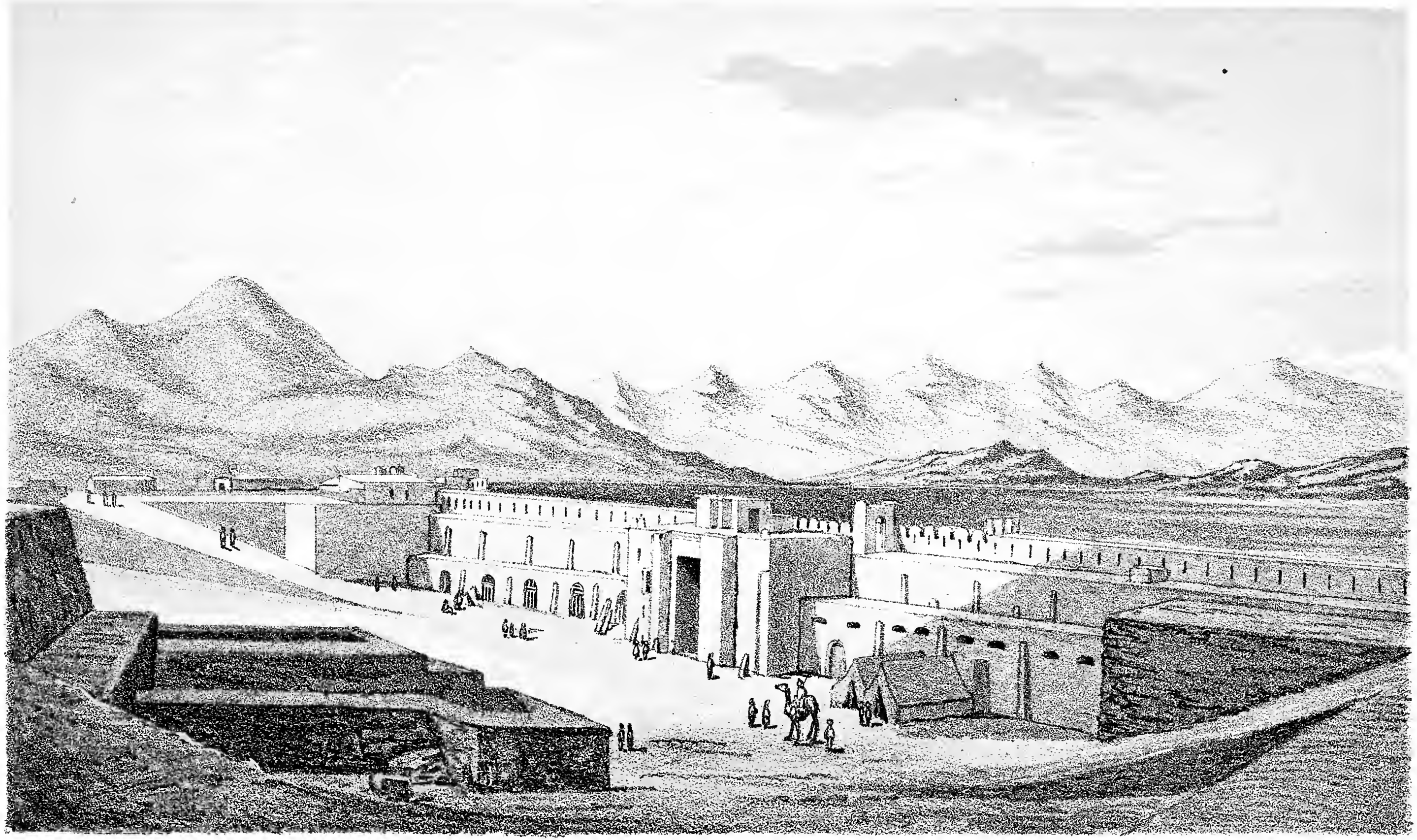
Again, that gallant veteran, Sir George Pollock, who in 1843 led the avenging army back into Afghanistan and recovered our prestige. And last, and greatest of all, the late Sir Henry Lawrence, whose undying fame needs no feeble words of mine to bring to your remembrance. All these are names of which artillerymen may well be proud.

I have now concluded my story, and have to thank you very sincerely for the kind and patient attention you have given to my statement.

I do not know how far I have been able to carry you with me in my views. I am aware that the subject is a difficult and a wide one, and is capable of being viewed in many aspects. Indeed, in the presence of several officers who have served long on the frontier, I feel as if I were almost guilty of presumption in setting forth my ideas as I have done. My object, however, has been simply to endeavour to explain the position of affairs in Central Asia, and to point to what seems to me our proper policy in that part of the world. It will be a great satisfaction to me if I can feel that I have given you any information, or have been able to throw any light upon this important and interesting subject—one of which we have not heard the end.

To those who are interested in the "Central Asian" question, the following list of works may be useful, and they have been consulted in drawing up this paper:—

1. Report showing the relations of the British Government with the Tribes on the North-West Frontier of the Punjab, from annexation in 1849 to the close of 1855. 1856.
2. Letters of General John Jacob. 1856.
3. Treaties, Engagements, and Sunnuds, India, Vol. II. The Punjab and the States of the Punjab Frontier. Aitchison. 1863.
4. Travels in Central Asia. Vambery. 1864.
5. The Russians in Central Asia. Michell. 1865.
6. The Russians in Central Asia. "Quarterly Review," October, 1865.
7. Selections from the Records of the Government of India—Foreign Department—The Peshawur District. By Major James, C.B. 1865.
8. Central Asia. "Quarterly Review," October, 1866.
9. Foreign Policy of Sir John Lawrence. "Edinburgh Review," Jan. 1867.
10. The Oxus and the Indus. Major Evans Bell. 1869.
11. A Retrospect of the Afghan War. By Major-General Sir Vincent Eyre, K.C.S.I., C.B., R.A. 1869.
12. Our Northern Frontier. Captain A. F. P. Harcourt. 1869.
13. Masterly Inactivity. H. Wyllie. "Fortnightly Review," Dec. 1869.
14. The Afghan Tribes on our Trans-Indus Frontier. "Westminster Review," October, 1869.
15. The North-West Frontier of India. George Campbell. "Journal of the United Service Institution," Vol. XIII. 1869.
16. Sketches of Central Asia. Vambery. 1868.
17. The Russo-Indian Question. Trench. 1869.



Lithographed at the Royal Artillery Institution.

INTERIOR OF THE FORT–PESHAWUR
LOOKING NORTH WEST.

Lithographed at the Royal Artillery Institution

VALLEY OF KOHAT—LOOKING SOUTH.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Lithographed at the Royal Artillery Institution

18. A Political Survey. Grant Duff, M.P. 1868.
19. The Central Asian Question; a Series of Letters by "England." Reprinted from the "Friend of India."
20. On the Transit of Tea from North-West India to Eastern Turkestan. "Proceedings of Geographical Society," July 20, 1869.
21. The Central Asian Question. By General Romanoffski. "Times," March 16th, 26th, and 27th. 1869.
22. Speech of Lord Lawrence in the House of Lords, April 19th, 1869.

NOTE.—The two sketches are intended to illustrate the frontier scenery. One is of the valley of Kohat, looking south from the Afreedie Mountains, and shews the isolated position of the station of Kohat, in the midst of the plain in close proximity to the Afghan Mountains. The other is taken from the interior of the fort of Peshawur—the mountains on the left being those which overhang the Kyber. The fort is not a strong one, and merely contains our ammunition and reserve stores. The troops are stationed on the plain outside. In the distance are the snowy ranges of the Hindoo Koosh.

THE
CONSTRUCTION OF OUR HEAVY GUNS.

BY

CAPTAIN F. S. STONEY, R.A.,

ASSISTANT SUPERINTENDENT, ROYAL GUN FACTORIES.

Difference between the "Original" Construction and the "Cheap" or present one.

UNTIL April, 1867, all our rifled muzzle-loading guns were built up like the breech-loading guns—of wrought-iron coils shrunk together successively on Sir William Armstrong's original plan. The plan proposed by Mr. R. S. Fraser, of the Royal Gun Factories, was then adopted; but some guns in former estimates being still in arrear,* manufacture on the original construction did not cease altogether until March, 1868.

Mr. Fraser's plan is, as stated in a previous paper,† an important modification of the original method, from which it differs principally in building up a gun of a few long double or triple coils instead of several short single ones and a forged breech-piece.

For example, in addition to the steel barrel and cascable, a "Fraser" gun of the pattern most generally followed has only two separate parts, viz. the breech coil and *B* tube (or as they are sometimes familiarly called, the "jacket and trousers"), whereas the 9-inch gun of original construction has a forged breech-piece, a *B* tube, a trunnion ring, and seven coils—ten distinct parts—which are shrunk on separately (see Plate II.)

The formation of a double or triple coil is a simple forge operation, but great expense is saved by its means, as there is so much less surface to be bored and turned, for each coil having to be made as smooth as glass and at the same time true to gauge (to a thousandth of an inch), it follows that it must be cheaper to have a few thick ones in lieu of many thin ones. For the same reason there is also less waste of material; for although the turnings are afterwards worked up into bars, iron in its scrap state is only worth one-third of its forged value.

Moreover, time and labor are also saved in having fewer pieces to move from workshop to workshop; for instance, in the case of a gun of original

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* Two 12-inch, forty 9-inch, three 7-inch of 7 tons, and forty-six 7-inch of $6\frac{1}{2}$ tons.

† "Theory of Gun Architecture." See Vol. VI., p. 335.

construction, when a coil was shrunk on, the mass had to be moved from the shrinking pit to the turning lathe, and turned down for the next coil, and so on, coil by coil, until the gun was built up; but in the new construction only two separate shrinkings are required, and it is computed that where fifty tons were moved in the former case, only seven are moved in the latter.

From these circumstances, combined with the employment of cheaper iron, a "Fraser" gun can be made at two-thirds of the cost of a gun of the same nature as originally manufactured.

But, it will be naturally asked, is this cheap construction as strong as the old one?

To answer this question in the most satisfactory form, it will be better to pass over the theoretical grounds which have already been discussed (see note † on previous page), and simply to state the facts of the case gathered from the trials of strength to which both systems were subjected, and then leave the reader to judge for himself.

First mention of Cheap Guns, and trial of 9-inch Guns on this plan.

So far back as October, 1864, the Secretary of State for War drew the attention of the Ordnance Select Committee to the fact that a large number of 12-ton guns would probably be required for coast defences, and that it was advisable to adopt some cheaper mode of construction than the Armstrong method then in vogue.

Colonel Campbell, R.A., Superintendent Royal Gun Factories, being applied to by the Committee, explained that it was quite possible to reduce the expense hitherto incurred in the construction of wrought-iron guns, by the employment of steel with external coils reduced in numbers, and forged from iron of a cheap quality,* and subsequently he submitted tracings of two 9-inch guns on this plan, one with a steel barrel (like the present 8-inch Mark II.) and one with a wrought-iron barrel; but both had breech-pieces, and the *D* and *C* coils were not hooked together. The tracings were approved, and he was directed to manufacture the guns accordingly, 21st October, 1864.

They were tested in 1865. The gun with the iron barrel (Expl. No. 287), burst at the 104th round; but the Ordnance Select Committee expressed their opinion that the failure was one which need not shake confidence in the cheap method of construction, and in their report, 27th December, 1865, recorded their belief, founded on the trial of both guns as far as it had gone, that either gun was strong enough for all service purposes, and likely to be nearly or quite equal in endurance to the guns as previously constructed, and they thought the new construction should be introduced by degrees, and not entirely supersede the old method until its uniformity had been established by the proof of a considerable number of larger guns.†

The trial of the second gun (Expl. No. 286), was continued, and burst at the 400th round, the steel tube having cracked some rounds previously.

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* Extracts from "Proceedings of O.S.C." Vol. II. p. 230.

† Extracts from "Proceedings of O.S.C." Vol. III. p. 383.

The failure of a 9·22-inch gun of the original construction (Expl. No. 222), when compared with this 9-inch gun on the cheap plan, was in favor of the latter, as this table shews:—

Calibre. ins.	Average charge of powder. lbs.	Projectile. lbs.	Burst at round.
9·22	39·88	217·33	402
9·0	42·81	253·25	400

One-fourth of the guns above 7 tons weight for 1866–7 were then ordered, with the concurrence of the Admiralty, on the cheap construction.* And further, in reporting on the general question, 25th June 1866, the Ordnance Select Committee† stated that the guns of the then service (*i.e.* original) construction were fully equal to the requirements of the service, and were not exceeded in strength and durability by those of any other known construction or material; but, as a measure of precaution, *the service of the 9-inch gun should be limited to* 400 *rounds, of which not more than* 150 *should be with battering charges.*

Second Trial of 9-*inch Guns determined upon.*

From the result of the previous trials, the Committee repeated that the guns of cheap construction were not inferior in strength to those on the more expensive mode; but recommended further trials with 9-inch guns, including those on a newer plan without forged breech-pieces, which Mr. Fraser, from the experience recently gained, was led to submit, and the following five 9-inch guns were finally entered for trial:—

Expl. No.	329.	Original construction.
"	330.	"Fraser's," without breech-piece, but reinforced with a triple coil, thick steel barrel.
"	331.	"Fraser's," without breech-piece, but reinforced with a triple coil, iron barrel.
"	332.	"Fraser's," without breech-piece, but reinforced with two double coils, thin steel barrel.
"	333.	do. do. do.

The four first guns had the Woolwich rifling, the last Lancaster's oval bore.

64-*pr.* B *and* D *Guns tested.*

But in the mean time the navy were crying out for cheap 64-prs., and two "Fraser" guns were doomed to rapid destruction, to ascertain whether either pattern would answer. One (Expl. No. 320) was known as the *B* pattern, the other (Expl. No. 317) as the *D*. Each had a coiled wrought-

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* Extracts from "Proceedings of O.S.C." Vol. IV. p. 76.

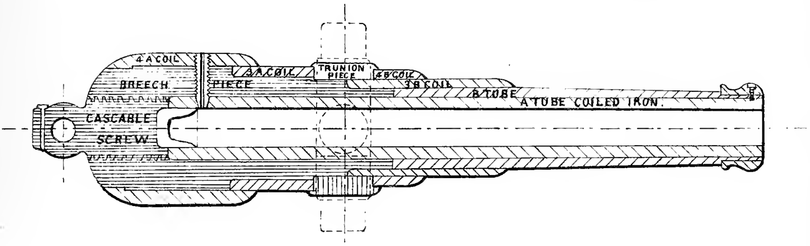
† Extracts from "Proceedings of O.S.C." Vol. IV. p. 192.

ROYAL GUN FACTORIES.

ORDNANCE WROT IRON MUZZLE LOADING GUN 64 PR 64 CWTS. R.

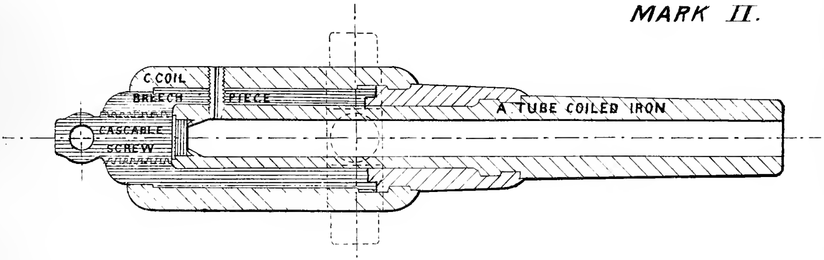
(*Scale, 3/8 Inch = 1 Foot*
For general outline)

MARK I.



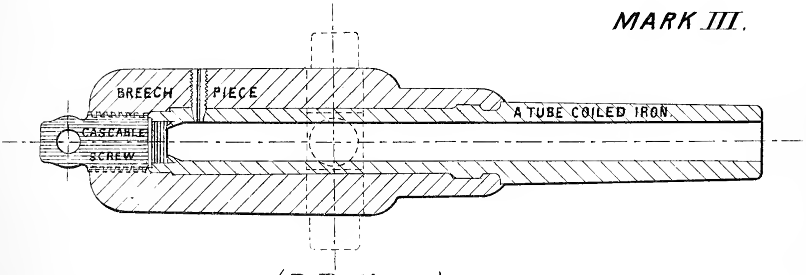
(*Original Construction*)

MARK II.



(*B. Pattern.*)

MARK III.



(*D. Pattern.*)

Lithographed at the Royal Artillery Institution.

iron barrel, double at the chase but single at the breech end, which was closed with an iron plug backed up by a cascable. The *B* gun had in addition a forged breech-piece, a *C* coil, and a breech coil, consisting of a double coil and trunnion ring welded together; whilst the *D* gun had no forged breech-piece, but a triple coil, trunnion ring, and *C* coil all in one.

These experimental guns fired each 2000 service rounds (charge 8 lbs.), and abnormal charges being then used, the *B* gun burst into 38 pieces, after a total number of 2270 rounds, and the *D* gun after 2211 rounds blew out its inner barrel, leaving the breech portion on its carriage and still sound.

The Superintendent Royal Gun Factories, and the Ordnance Select Committee, considered these results as highly satisfactory.

The *B* gun burst no doubt into several pieces, *as all guns with a forged breech-piece are likely to do,* but it gave timely warning of its approaching dissolution.

The *D* gun was more satisfactory still, as the trial proved it possessed the very strongest form of exterior, the gun having fired many rounds after the inner barrel was thoroughly broken up.*

Adoption of the Cheap Plan as the Service Construction.

The great success of the cheap construction, as displayed by 64-prs., combined with its favourable progress in the 9-inch guns under trial, induced the Ordnance Select Committee to recommend (7th December, 1866), that *half* the guns for 1867–8 should be on the Fraser method, and it was subsequently approved (without waiting for the issue of the trial of the five 9-inch guns), by War Office and Admiralty, that all the guns estimated for that year should be on this plan.

The trial, however, of the 9-inch guns was carried on in 1867 with the first three on the list—*i.e.* Expl. Nos. 329, of original construction, and 330 and 331 of Fraser construction—and by the end of that year each of these three guns had fired 500 rounds with battering charges (43 lbs.) as appointed, the cheap guns having stood the ordeal quite as firmly as their expensive brother.

The other two guns (Expl. Nos. 332 and 333), both of *F* (Fraser) construction as described, were ordered to fire each 400 rounds of full charges (30 lbs.) and 200 of battering (43 lbs.), a test which they successfully accomplished by the 17th of September, 1868.

In the mean time many "Fraser" guns had been proved and issued for service, the majority being on the pattern of Expl. No. 330—*i.e.* with a steel tube, and reinforced with a triple breech coil.

Bursting of a 9-inch Gun at Proof.

Of the 9-inch guns alone about 100 had passed proof, and the soundness of the system was generally recognised—but lo! on the 25th of September of the same year ('68), a 9-inch gun of the identical pattern burst violently

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* Extracts from "Proceedings of O.S.C." Vol. IV. p. 356.

the first round of proof, and many were startled by the occurrence, as it was commonly believed that a coiled wrought-iron gun would not burst explosively, but better informed people knew well that instances had already occurred of their doing so—for instance, the 9·22 inch of original construction before alluded to, burst in this manner with a service charge, and two 40-pr. B.L. guns actually went to atoms whilst proving vent-pieces; these guns were no doubt old and worn out, and had given timely indications of their dangerous condition, but it was also known that new guns would go in the same manner, if their elasticity or strength were subjected to a too sudden or a too excessive strain, such as that exerted by the action of some violent explosive like gun-cotton or nitro-glycerine, or from an intolerably large charge of powder. Now, the bursting of the 9-inch gun at proof, was evidently due to a defective tube, for one of the ills which a steel barrel is heir to are cracks, imperceptible and often very deep, caused probably by the unequal rate of cooling of some of the parts during the process of toughening. A gun with a tube so diseased may well be compared to "a goodly apple rotten at the core;" such was the gun in question, and it was no wonder that the powerful proof charge (53¾ lbs.) should have blown it to pieces at the first round.

To prevent, however, a similar occurrence, every steel tube is now subjected after toughening to a water pressure on the interior of 8000 lbs. per square inch, which is sufficient it is thought to detect any latent cracks. Any gun that has stood the proof may safely be relied on as free from these dangerous defects.

Final Trial of 9-inch Guns.

In order, however, to set the matter at rest, further trials with "Fraser" 9-inch guns were recommended and approved, the results of the former experiments being deemed inconclusive, as the vents of the guns happened to be at the rear—which fact causes a less strain on the piece than when it is some distance forward, as in the service guns. Expl. No. 332 gun, which had already fired 400 rounds with full charges (30 lbs.) and 214 with battering charges (43 lbs.) with the rear vent, was accordingly turned upside down and vented in the service position, and subjected to a crucial test of 500 rounds with battering charges at 50 rounds a-day, which it finished most triumphantly, 11th March, 1869; so that this gun fired altogether 1114 rounds, of which 714 were with battering charges—a great increase on the number of rounds to which the service of 9-inch guns was limited in 1866!

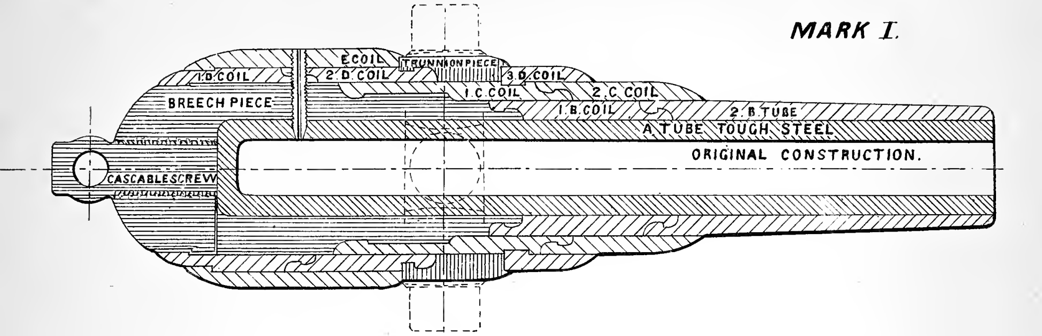
A new 9-inch gun, Expl. No. 368, of the service pattern—that is, reinforced with a triple coil like the gun that burst—was then subjected to the same test as No. 332 had undergone, in order to ascertain which of the two modifications of the new construction was the stronger. It fired 400 rounds with full, and 207 with battering charges, with the vent in rear; it was then turned over, vented in the service position, and the second part of the programme, namely 500 rounds with battering charges, was commenced. At the 100th round the impressions showed a faint crack in the steel tube at the crown of the bore. This increased regularly to the 401st round—that is, the 1008th round of all—when the gas escape indicated that the

ROYAL GUN FACTORIES.

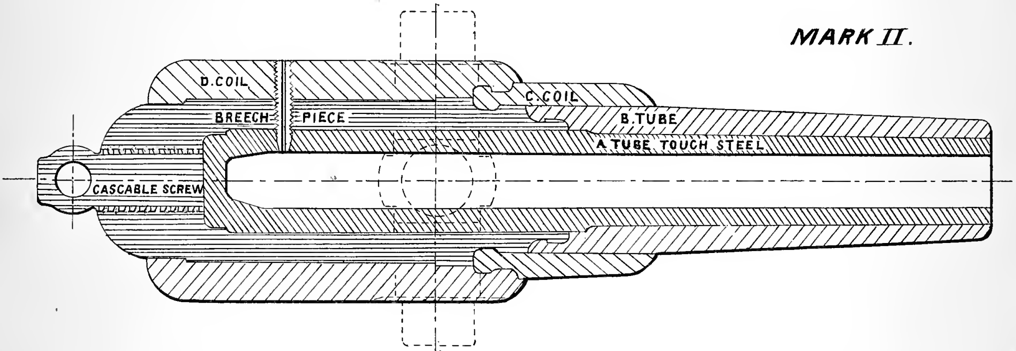
ORDNANCE WROT. IRON MUZZLE LOADING GUN 9 INCH 12 TONS R.

(Scale 3/8 Inch = 1 Foot.
For general outline.)

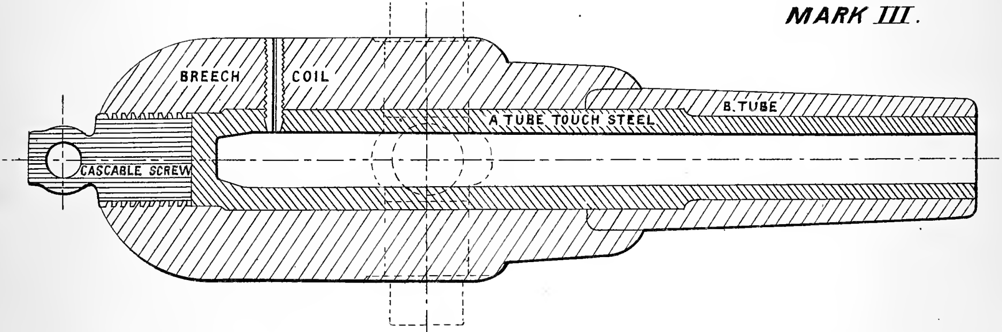
MARK I.



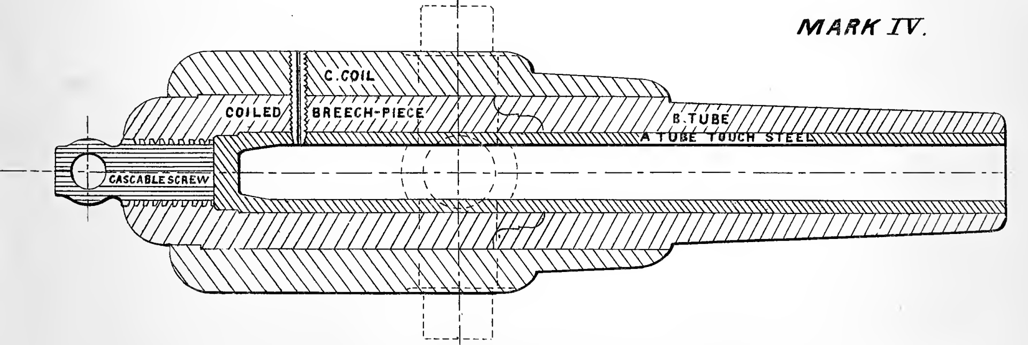
MARK II.



MARK III.



MARK IV.



Lithographed at the Royal Artillery Institution.

breech end of the tube was split right through. After this the gun fired 41 rounds, and then at length, at the 1049th round, the *A* and *B* tubes were bodily forced about an inch forward. This closed the vent, and consequently put an end to the trial.

The result was deemed most satisfactory, not only because the steel tube failed so gradually, but because the great strength of the outer fabric—the point at issue—was proved beyond all doubt by the gun actually firing forty-one rounds after the tube was split through, and yet remaining sound exteriorly.

Both guns behaved so exceedingly well under trial, that the authorities were left in the pleasant dilemma of not knowing which pattern to choose :—No. 332, with a steel tube two inches thick, and reinforced with two double coils, survived the trying ordeal. No. 368, with a steel tube three inches thick, and reinforced with one massive triple coil, did not it is true complete the test, but it refused to yield although its tube was split.

With respect to the precise pattern for future construction, it would perhaps have been the safest course to have continued firing No. 332 gun, and then if it did not blow its breech off (its tube being so thin), or burst explosively without giving ample warning, to adopt it as the pattern of all the heavier natures. The authorities, however, have decided on constructing 7-inch and 8-inch guns as before, on the No. 368 type, but to make 9-inch guns and upwards on the No. 332 type.*

Present state of the question.

The question then stands thus :—Up to April, 1867, all our heavy guns were made on the original construction, like the 9-inch gun, Mark I., and from that date up to the present nearly all have been made like the 9-inch gun No. 368, or Mark III.—*i.e.* consisting only of four parts, viz. steel tube, cascable, *B* tube, and breech coil—and 7-inch and 8-inch guns will still be made in the same way. Of all these, the 9-inch gun is the most important; it is very powerful for its weight, and has been made in considerable numbers; it is therefore taken as a type of the most common form of the present construction, and its manufacture will now be described in detail.

The alteration in future manufacture for 9-inch guns simply consists in having a thinner steel tube and two coils on the breech (see Mark IV.) instead of one triple one; or perhaps the difference in construction will be more readily remembered by using the familiar illustration, and saying that in the former instance the steel tube is enveloped in "jacket and trousers," whilst in the latter it is thinner, and has "jacket, waistcoat, and trousers." The higher natures are made in the same way, but have a "belt" in addition.

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* This pattern costs about the same as the other, the extra expense of making two breech coils being compensated for by the lighter steel barrel. Good reasons for preferring this construction for heavy guns would be that the inner coil can be made of twice rolled (*i.e.* superior) iron, and with greater perfection, and also that the thinner the tube the more will it be compressed by the shrinking, and strengthened accordingly.

As to 9-inch guns, Mark II., only a few have been made, as the experiments (see p. 409) proved that the longitudinal strength of a *forged* breech-piece was superfluous when a solid-ended steel barrel and long or jointless breech coils were employed, and moreover that it was not only a source of circumferential weakness, but rendered the gun liable to burst explosively.

The following table* shews the number of each nature on the various constructions issued up to the 17th February, 1870:—

	Original.	"Fraser," with forged breech-piece.	"Fraser," with triple breech coil.	"Fraser," with two breech coils.†	Total.
13-inch, 23 tons‡	2	—	—	—	2
12 " 23 "	4	—	—	—	4
12 " 25 "	—	—	11	—	11
10 " 18 "	—	—	17	—	17
9 " 12 "	191	26	134	19	370
8 " 9 "	76	6	27	—	109
7 " 7 "	50	2	61	—	113
7 " 6½ "	328	20	226	—	574

Details of the Manufacture of a 9-inch Gun, Mark III.

The gun consists of:—

An inner barrel or tube of steel.
A *B* tube.
A breech coil.
A cascable.

The Inner Barrel.

The inner barrel, which when in the gun weighs only 36 cwt., is made from a solid forged cylinder of cast steel weighing 67 cwt., which is supplied to the Royal Gun Factories by the contractors, Messrs Firth, of Sheffield. Casting is necessary, not only for the purpose of obtaining a sufficiently large block of steel, but also for making the block homogeneous and uniform

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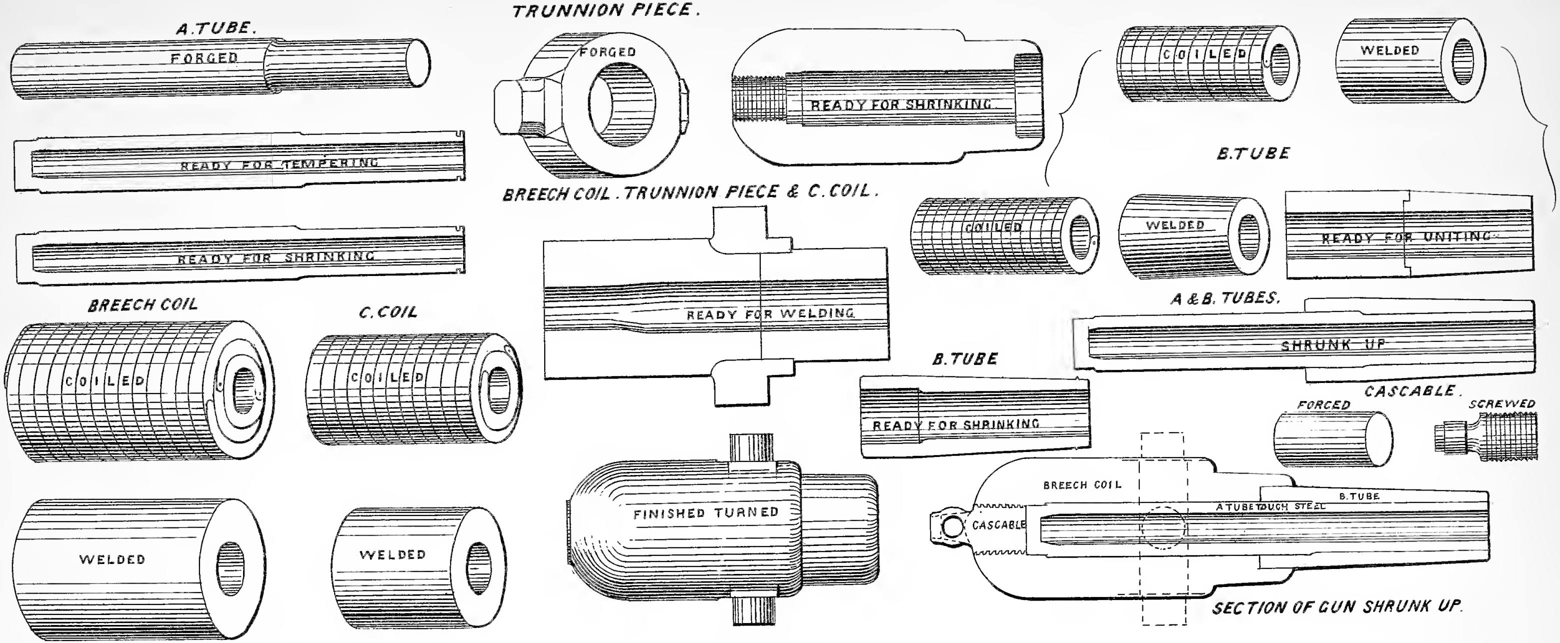
* I have purposely excluded 64-prs. from the table, because they can hardly rank now as heavy guns, and moreover they differ from all the higher natures in having coiled iron barrels, shunt rifling, and a peculiar construction—a different class in fact. There are 432 64-prs. of 64 cwt.; of these 151 are on the original construction (or Mark I.), 50 *B* pattern (or Mark II.), and 231 *D* pattern (or Mark III.); see plate 1. There are in addition 212 64-prs of 71 cwt. converted (at Elswick) from 8-inch cast-iron S.B. guns of 65 cwt., and more are undergoing conversion in the Royal Gun Factories.

† *i.e.*, two breech coils shrunk one over the other; in the 9-inch gun (Mark IV.) the inner one is a single, and the outer, to which the trunnion and *C* coil are welded, is double. In the 10-inch (Mark II.) both breech coils are double.

‡ Rifled guns of 7-inch calibre and upwards are officially designated by their calibre and weight, but guns below 7-inch calibre are known by the weight of the shot. The weight of the gun is always expressed in tons if 5 tons or upwards, otherwise in cwts. To designate fully any gun, it should be stated whether it is B.L. or M.L., and the mark should be specified, thus:—The 7-inch rifled M.L. gun of 7 tons, III.

PL. III.



DIAGRAM

ILLUSTRATING THE VARIOUS STAGES OF MANUFACTURE OF A 7 INCH, 8 INCH OR 9 INCH R.M.L GUN (MARK III.)

Lithographed at the Royal Artillery Institution

in density. Forging or drawing out the cast block imparts to it the desirable properties of great solidity and density.

The cylinder is manufactured thus :—A large quantity of puddled steel having been broken up, the pieces whose fine fracture indicates a mild nature, are placed with a little flux in a number of plumbago crucibles containing about 45 lbs. each. An ingot for a 9-inch gun weighs 86 cwt., so 212 crucibles are required; these are placed in holes in the floor, underneath which are air furnaces. The metal is melted in about three hours. The crucibles are then lifted, one by one, from the furnaces by means of tongs, and wheeled quickly to the mould; several men are employed in rolling up and pouring in the metal. They are obliged to keep up a continuous flow of molten metal, else the casting would not be homogeneous —hence the operation is at once important and resplendent; it lasts about twenty minutes.

The mould is of cast-iron, and smeared inside with some non-conducting substance, a mixture of black lead generally. That for the 9-inch ingot is 5 feet long and 2 feet square. The metal cools gradually, after which about $\frac{1}{4}$th is cut off, and the lower end, being the denser, is marked for the breech.

The block thus formed is drawn out by a series of heatings and hammerings which occupy several days, to a cylinder sufficiently long for an inner barrel, in which state it is sent to the Royal Gun Factories, where it is subjected to the following tests and treatment.

A slice is cut off from the breech end and divided in pieces for testing. Some of these are flat bars, 4 inches long and $\frac{3}{4}$ by $\frac{3}{8}$ in section, and others are of the shape usually tested in the machine for tensile strength and elasticity. Three of the former are marked respectively *S*, *L*, and *H*. One end of the *S* or soft (*i.e.* untempered) piece is gripped in a vice, whilst the other end is hammered down towards it, to ascertain that the steel, by bearing this bending without cracking, is naturally of the mild quality required. The *L* and *H* pieces are raised to a low red, and high heat respectively, immersed in oil, and, when cold, treated in a similar manner.

Whichever of these pieces bears the hammering best, determines the heat at which the whole tube is to be toughened. Should neither piece answer, others at intermediate temperatures are tried, and if all fail, the block is returned to the contractors; but some specimen having succeeded, as is generally the case, two of the remaining pieces—one in its soft state, and the other toughened at the ascertained temperature—are tested for tensile strength and elasticity. The soft material should begin to stretch permanently at 13 tons per square inch, and break at 31 tons. The toughened piece should begin to stretch at 31 tons, and break about 50. The permanent elongation is also taken, but it is not considered necessary to lay down any limits in this respect.*

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* It may seem remarkable that the colour at which a razor, a chisel, or a watch-spring must be tempered is definitely fixed, and yet that the heat for toughening a gun-barrel should vary in shade from a blood-red to a bright cerise. Now, did the temperature depend alone on the amount of carbon in the steel, it would appear best to toughen every barrel at a bright heat, for the less carbonized, or in other words the milder the steel, the higher is the temperature at which it toughens

A steel ingot or block which stands all the foregoing tests is "rough turned," care having been taken to fix it truly central in the lathe by means of a chuck at the muzzle, and the small projection at the breech, round which the slice for testing was cut away. In this operation a lip or collar is formed at the muzzle, to facilitate the lifting of the tube in and out of the furnace and oil bath. The machine is a turning lathe on the ordinary principle. It admits of two cutters working simultaneously, and is capable of doing rough or fine turning as required. The fine turning is not done until the *B* tube and breech coil are gauged and ready to be shrunk on.

The block is next bored roughly from the solid, 8¼ inches of diameter being taken out by one cut in segmental chips ⅛th of an inch thick. The boring head is the ordinary shaped "half-round bit" with one pointed cutter set angularly, and three steel burnishers. The average time for this rough boring is 56 hours. After this the chamber (which is in all Fraser guns), is roughly formed by means of a cylindro-conoidal head with one long cutter and six steel burnishers, two on the taper part and four on the cylindrical. Average time 12 hours. Rough and fine boring, forming the chamber, and broaching, are all effected in the same horizontal machine (the difference being in the shape of the boring head and cutters), in which the barrel revolves, while the boring head, guided by bearings at the muzzle, simply progresses down the bore, being fed to its work by a long screw which passes through a nut in the sliding saddle to which the bar is fixed.

The tube thus formed is now ready for toughening in oil. This consists in heating the roughly bored tube (from 4 to 5 hours) to the approved temperature in a vertical furnace, and then plunging it bodily into an adjacent bath of rape oil, in which it is allowed to cool and soak till next day, generally 12 hours or more.

The following graphic description of the operation is extracted from an excellent treatise on "The Management of Steel," by Mr. George Ede, of the Royal Gun Factories:—

"The tube is lifted by a powerful crane, and placed in a perpendicular position in an upright furnace; an iron coil, about 6 inches in depth and about 1 inch longer in diameter than the diameter of the block of steel, is placed upon the fire bars at the bottom of the furnace for the block of steel to rest upon; beneath this iron coil is placed a piece of plate iron, to prevent the cold air as it passes through the bars coming in contact with the extreme end of the block of steel, and in order to obtain an uniform temperature at the extreme end of the block of steel, this iron coil is filled with wood ashes. The iron coil becomes filled with the wood ashes while heating the furnace to a red heat with refuse wood, previous to putting the steel in the furnace. After the block of steel is placed in the furnace, the bottom end of it is then surrounded with some short blocks of wood, the damper is not lifted until the extreme end has acquired a low red heat, after which the damper is lifted,

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most satisfactorily; but it is a fact that the denser the steel is—*i.e.* the more it is hammered in the process of drawing out—the less heat does it require for successful toughening; hence each individual barrel must be tested. Doubtless a little more experience will teach us the exact mildness and density suitable for a steel barrel, and the proper temperature to which it should be raised, before being immersed in the oil.

and the block of steel is then entirely surrounded with longer pieces of refuse wood thrown in from the top of the furnace.

"After the steel has acquired the proper uniform temperature throughout, the travelling crane is brought over the furnace; the cover belonging to the top of the furnace is then removed, after which a pair of large iron tongs attached to the crane fasten themselves at the top end of the steel block or tube. The tongs are so constructed that the heavier the weight, the tighter they grip the steel; still it is found necessary to turn a small collar upon the end of the block, to prevent the tongs slipping by the weight. After the tongs have fastened themselves upon the block of steel, it is drawn out of the furnace and sunk into a large iron tank about 20 feet deep, containing several hundred gallons of oil. The heated steel in passing into the oil will sometimes cause the surface oil to take fire, which, after the whole body of the steel is beneath the surface of the oil, is extinguished by closing the covers at the top of the tank, and spreading a piece of canvas over them. The tank has a water space around it in which a supply of cold water permeates for the purpose of keeping the oil cool. The best way to describe the tank is to state that it is an old steam boiler, sunk endways and perpendicular in the ground."

The process of toughening has a bad effect in two ways; it not only warps the steel a little, but frequently causes the surface to crack. The barrel must therefore be slightly turned and bored, to make it straight inside and outside, as well as to remove any flaws that may have been generated. This second boring (performed with a cylindrical boring head, fitted with five long edged cutters and five wood burnishers), increases the diameter to 8·6 inches. The time required for second boring—slight as is the cut—is 25 hours, the steel being much harder after toughening. By these means the cracks are generally removed, but several tubes have been rejected in consequence of flaws still appearing to penetrate to a dangerous depth, and lest there should be any not visible to the eye, the steel barrel is subjected as follows to the water test before referred to.

The tube being recessed on the face for a gutta percha ring, and inside the muzzle for a leather cup, is fitted with these washers and placed in a horizontal hydraulic press, and screwed tightly up between two cast-iron heads by means of two strong wrought-iron bars, extending from head to head, and fitted with nuts at the outside, worked by a long spanner. The tube is then filled with water from the main through the hole in head and leather cup, and then the pipe of the press is fixed into the hole, and the pump is set to work by steam. The pressure on the interior is shown by two indicators, one vertical and one horizontal, so as to check one another. When 3½ tons per square inch is thus indicated, the pressure is withdrawn, and if no flaw has been detected by the formation of moisture on the exterior, the tube is considered safe and sound. The barrel is left in this state until the *B* tube is ready to be shrunk over it.

The B *Tube.*

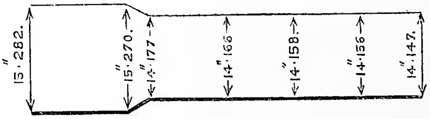
The *B* tube is composed of two single and slightly taper coils united together. The first coil is formed of two bars joined together—one 16 feet long and 5½″ × 4¾″ × 4⅝″ in section, the other 33 feet by 5″ × 4½″ × 4″. The second coil is also composed of two bars—one 18 feet by 4½″ × 4½″ × 4″, and the other 31 feet by 4″ × 4″ × 3½″.

The two coils, being made and welded in the usual way, they are faced and reciprocally recessed to the depth of about one inch, and then united together endways by expanding the faucit of one coil by heat, and allowing it to shrink round the spigot of the other. This sticks the two coils sufficiently tight together to admit of the tube thus formed being placed upright in a furnace, whence, when it arrives at a white or welding heat, it is removed to a steam hammer, and receives on its end six or seven pressing blows which weld the joint completely. The weight of the tube in this rough state is about 55½ cwt., but when finished as it is on the gun it only weighs 31 cwt.

The *B* tube is next rough turned, in which process a rim is formed near the muzzle for the convenience of lifting the tube in "shrinking." After this, the tube is rough and fine bored in the same horizontal machine. The tube is fixed truly central in a saddle capable of sliding along the frame of the machine. The boring bar, having two cutters placed adjoining and opposite, is passed through the tube and fixed at each end of the machine. The bar revolves while the saddle moves forward, and thus the boring is effected. The difference between the rough and fine cutters is (as generally the case) that the former are deep and narrow, and the latter shallow and broad.

The interior of the *B* tube having thus been brought to the degree of smoothness requisite for close contact with the steel barrel, is gauged every twelve inches down the bore, and also at the shoulder. To the measurements thus obtained, the calculated amount of shrinkage (0″·003 at the muzzle, and increasing up to 0″·03 at the other end), is added; a plan is made out according to which the exterior of the *A* tube (or rather that portion of it on which the *B* tube is to go) must be turned down, in order that it shall be exactly larger than the bore of the tube by the required amount of shrinkage at the respective parts.

The plan (as illustrated by the annexed drawing), is made on a slip of paper, and together with a corresponding series of accurately measured horseshoe gauges, is furnished to the turner, who turns down the muzzle end of the *A* tube accordingly.



The reason an *inner* tube is turned to suit an exterior one, instead of the latter being bored to suit the former is, that it is much easier to turn than to bore to very exact dimensions, on account of the great command which the operator has over the turning lathe, and the facility he has of testing his work by gauges, and correcting it by emery powder and oil.

The Breech Coil or Jacket.

The breech coil or jacket is composed of a triple coil, a *C* double coil, and a trunnion ring, made and welded together as follows:—

The triple coil is made of three bars all of the same section, viz.—$4\frac{1}{2}'' \times 4\frac{1}{2}'' \times 4''$, but differing of course in length, the first or innermost one being 78 feet, the second 118 feet, and the third 158 feet in length, the middle one being coiled in the reverse direction so as to break joints. In order to weld its folds, it is placed in a furnace for about ten hours, at the end of which time it is at a welding heat, whereupon it is rapidly transferred to a powerful hammer, and receives a few smart blows on its upper end, which close the folds longitudinally. A mandril somewhat larger in diameter being then forced down it, it is turned on its side, and well hammered all round to make it dense. It is replaced in the furnace for about six hours, and the same process repeated at the breech end, but with a smaller mandril.

When cold, the ends are faced and the outer coil is turned down at the muzzle end to form a shoulder 14″ long for the reception of the trunnion ring.

The C *coil* is made of bars of the same section as those used for the triple coil. The inner bar is 46 feet in length, and the outer one 69 feet. This double coil being welded, has a shoulder formed on the lower end about 9 inches long and ¾ inch deep, so that it may overlap the trunnion in the welding.

The trunnion ring is made like all wrought-iron trunnion rings—namely, of slabs of iron consecutively welded together on the flattened end of a porter bar, and gradually formed into a ring by means of, first, a small iron wedge, which is driven through the centre and punches an oval hole, and then by a series of taper mandrils increasing in size, which make the hole sufficiently large and round. The trunnion ring has to be heated for each punching, and the occasion is used to hammer the trunnions roughly into shape, one of which is in continuation of the porter bar. Eventually the ring is cut off from the bar by means of strong blunt hatchets of steel hammered through it. The trunnion ring is next roughly bored out.

All three parts (breech coil, *C* coil, and trunnion ring), being thus prepared, the trunnion ring is heated to redness, lifted by a crane, and dropped on to the shoulder of the triple coil, which is placed upright on its breech end for the purpose.

While the trunnion ring is still hot, the *C* coil is dropped down upon the front of the triple coil, through the upper portion of the trunnion ring which was left projecting. The trunnion ring thus forms a band over the joint, and in cooling contracts round the two coils, and grips them sufficiently tight to allow of the whole mass being placed bodily in a furnace, where it is raised to a welding heat in about thirteen hours (see diagram, breech coil, trunnion ring, and *C* coil ready for welding).

The glowing mass is then quickly placed on its breech end under the most powerful hammer in the Department. Six or seven blows on the top suffice to amalgamate the three parts together; but to make the welding more perfect on the interior, as well as to obviate any bulging inside, a cast-iron mandril somewhat larger than the bore is forced down to within 20 inches of the breech end, a series of short iron plugs being used to drive it down. The mass is then reversed, and the mandril is driven out with the same plugs, which have fallen out in the tilting over.

The rough jacket thus made weighs over 16 tons, but this weight is reduced to 9 tons by the turning, rough and fine boring, &c., which are necessary to bring it to the proper size and shape.

The body is turned in a very powerful lathe, weighing, with its foundation, 100 tons, to the required shape. The operation takes sixty hours; consequently all the four big lathes, which are in a row, may be often seen at work together, and a fine mechanical spectacle it is.

It being impracticable to turn down the trunnion ring in a lathe, it is slotted smoothly down by a self-acting vertical machine with a double motion, one of which moves the jacket round for a fresh cut at every stroke of the tool which the other works up and down accordingly.

The trunnions themselves have yet to be turned down to shape; so the jacket has to be moved for the purpose to another machine—a break lathe—in which it is made to revolve on the axis of the trunnions while the sliding cutters act on their surface.

The jacket is next rough and fine bored in a machine like that used for the *B* tube, but stronger, and the front of the *C* coil is recessed on the inside to a depth of 9 inches, and broad enough to overlap the *B* tube.

Finally, the female thread for the cascable is cut by a machine in which the jacket revolves horizontally, while the cutter is fed forward by a copying screw—one pitch for every revolution of the jacket.

Building up the Gun, or shrinking the parts together.

The steel barrel and *B* tube being prepared for one another as described, are shrunk together in this manner:—The *B* tube is placed on a grating, and heated for about two hours by a wood fire, for which the tube itself forms a flue, until it is sufficiently expanded to drop easily over the muzzle end of the steel barrel, which is placed upright in a pit ready to receive it. The *B* tube is then raised, and the ashes, &c., being brushed from the interior, is dropped over the steel barrel by means of a travelling crane overhead. During the process of shrinking, a stream of cold water is poured into the steel barrel, to keep it as cool as possible, the water being supplied and withdrawn by a pipe and siphon at the muzzle. A ring of gas is placed at the muzzle or thin end of the *B* tube, to prevent its cooling prematurely, whilst jets of cold water play on the other end, and is gradually raised to the muzzle, for the purpose of cooling the whole tube consecutively from the breech end, which it is desirable should grip first, to ensure a tight fit at the shoulder. Moreover, were both ends allowed to contract simultaneously, the intermediate part of the tube would be drawn out to a state of longitudinal tension, and weakened accordingly.

The *A* and *B* tubes shrunk up (see diagram), are placed in a lathe, and while one cutter fine turns the *B* tube to its proper shape and dimension, another cutter fine turns the breech end of the *A* tube according to the plan of the breech coil, which has been made out on the principle already explained.

The shrinkage on the steel tube being $0''\cdot015$ at the extreme breech end, $0''\cdot02$ at the shoulder round the end of the bore, and gradually diminishing to $0''\cdot015$ at the point where the jacket abuts against the *B* tube, the overlapped portion of the *B* tube is given a shrinkage of $0''\cdot03$.

The half-formed gun, composed of *A* and *B* tubes shrunk up, being next placed standing on its muzzle in the shrinking pit, the jacket is heated for about ten hours, and shrunk on in the same manner as the *B* tube; it is however (being nearly of the same thickness throughout), allowed to cool naturally, and the cold water has to be forced up, fountain fashion, into the bore of the gun by a jet round which the muzzle rests.

The process of building up a 9-inch gun (Mark. IV.) will be very similar. There will be, however, three shrinkings instead of only two—viz. the coiled breech-piece on the breech end, the *B* tube on the muzzle end of the barrel, and then the outer breech coil over the inner one.

Processes after the Gun is Built up and before Proof.

These are:—

(1) Screwing in the cascable.
(2) Engraving the Royal cypher.
(3) Fine boring.
(4) Second rough cutting of chamber.
(5) Finished boring.
(6) Broaching of bore, and finishing of chamber.
(7) Lapping.
(8) Rifling.
(9) Temporary venting.

(1) *The cascable* is made of the best scrap iron. It is first forged into a simple cylinder; it is then turned, and a bevel thread cut on it. The button is turned on it, and a hole (which is afterwards enlarged into the loop), is drilled through one end, for the purpose of screwing it into the gun. The operation of screwing in the cascable requires great care, for the front of it must bear evenly against the end of the steel barrel, and in order that this may be the case, the end of the tube is smeared with red lead and the cascable screwed in tentatively, then unscrewed again, and filed down on the prominent parts, which are indicated by the absence of the red lead. This is repeated several times, until the equal distribution of the lead on the front shews that it bears evenly against the steel barrel.

At this stage, one round of thread is turned off the end of the cascable, so that there may be an annular space there, which in connection with a channel now cut along the cascable and across the thread, will form a gas escape, or tell-tale hole, in case the steel barrel should split at the end. The channel is about $\frac{3}{8}$th inch broad, and extends $\frac{1}{10}$th inch below the thread. In all guns made before the 1st September, 1869, the channel comes out directly under the loop; but in guns made since that date, it will be found at the left side of the loop, where it may be more easily noticed. The channel ought to be kept clear, and should the barrel be split at the end, some gas may be seen issuing from the hole; it is therefore advisable to keep an eye on this hole, and to cease firing should it give warning.

When at length the cascable fits properly, it is screwed in, and to prevent its moving, a hole $2\frac{1}{2}$ inches long and $\frac{3}{4}$ inch in diameter is drilled and tapped through the male and female threads in a slanting direction on the left side, and a plug is screwed in.

(2) While the cascable is being prepared, Her Majesty's monogram is engraved in front of the vent, the outline being marked on the gun by means of a perforated brass plate, rubbed over with charcoal.

(3) The gun is next removed to the boring mill, where it is fine bored to 8″·9.

(4) The chamber is next roughly bored out with the same boring head as before.

(5) The finished boring to 8″·997 is then performed.

The fine boring and the finished boring are effected with the boring head used in the the second rough boring, and together occupy twenty-six hours.

(6) In each boring the cutters wear a little during the operation, so that the bore becomes slightly taper towards the breech. This is of no consequence in an outer tube, as the exterior of the inner one can be turned accordingly, but the bore of the gun must be cylindrical, so broaching is employed—that is, boring the barrel by means of a cylindro-conoidal head, fitted with four long cutters at right angles to one another, and slightly tapering. The cutters are edged on the front as well as on the side, as the chamber is also finished off at this time, and for this latter purpose there is also a peculiar centre cutter for the very end of the bore.

(7) Still, however, the bore is not yet truly cylindrical, and "LAPPING" is resorted to. In this no cutter is used, but a wooden head, covered with lead and smeared over with emery powder and oil, is worked up and down at those portions of the bore which are indicated by the gauges as imperfect.

(8) The 7-inch M.L. guns are RIFLED with a uniform spiral—*i.e.* with grooves having the same amount of twist at every point of the bore; and all the higher natures with a uniformly increasing spiral—*i.e.* uniformly increasing from the breech to the muzzle. The advantage of an increasing spiral is, that the inclination of the grooves, being little or nothing at the breech, the projectile's initial motion is not checked by any resistance offered to the studs. The projectile therefore moves quickly from its seat, and relieves the breech a good deal from the strain of the discharge.

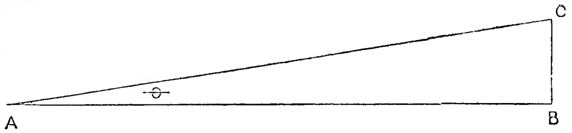
The machine is a horizontal one. The gun is fixed stationary in front of it, in a line with the rifling bar. The bar goes through a double motion of progression and partial rotation. Did it simply progress along the bore, a straight groove would be cut, but as we want a spiral groove, the partial rotation is necessary.

The progressive, or rather the backward and forward motion, is given by a fixed screw which stretches along the middle of the bed (as in the boring machine), and passes through a nut in the saddle to which the off end of the rifling bar is attached.

The proper amount of rotation is obtained by means of a rack which works into a pinion on the end of the bar, according as the bar progresses and slides across the saddle, as it is constrained to move along a tangent or copying bar which is inclined to the side of the machine at the required angle of the rifling. The greater therefore this angle, the quicker does the rack slide and the bar revolve, and the sharper is the twist of the groove cut in the gun.

In the case of a uniform spiral, the copying bar is straight edged, and the only thing necessary is to set it at the proper angle.

The angle is easily calculated thus :—



Take AB equal length of rifling due to one turn, and BC at right angles to it and equal length of one turn, or the circumference of the bore, then AC will be length of the total spiral, and θ the angle of the rifling and of the tangent bar.

$$\tan\theta = \frac{BC}{AB} = \frac{\pi \times \text{calibre}}{\text{number of calibres} \times \text{calibre}} = \frac{\pi}{\text{number of calibres}}.$$

For example, take the 7-inch gun, whose spiral is one turn in 35 calibres, then

$$\tan\theta = \frac{\pi}{35} = \cdot 0897;$$

$$\therefore\ \theta = 5^\circ\ 4' \text{ nearly.}$$

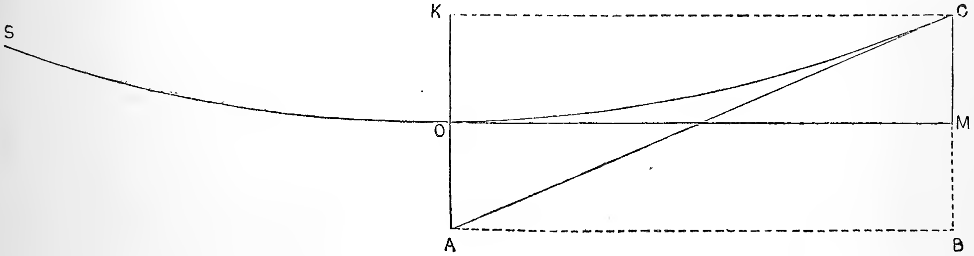
Did we require the actual amount of twist x in the bore, it is easily obtained from the proportion

$$AB : BC :: l : x,$$

l being the length of the rifled part of the gun, while we can form a good idea of the course of the groove along the bore, by supposing the position which the line AC would assume were the above figure wrapped round a cylinder equal to AB in length and BC in circumference.

For shunt rifling, as in the 64-prs., there must be a corresponding shunt on the copying bar, and for a uniformly increasing twist the edges of the bar must be curved accordingly; and as it is the property of the parabola to increase uniformly in curvature, we have adopted it as the curve of the rifling, its well known properties enabling us to easily construct a copying bar for any required spiral.

Thus, suppose we want to make a copying bar for the 9-inch gun, which has an increasing twist from 0 at the breech to 1 in 45 at the muzzle.



Let us assume OC as the required parabolic curve, and let OM drawn through the origin of the parabola, perpendicular to its axis, represent the length of the bore to be rifled. The tangent at C makes an angle with OM or AB equal to the angle of rifling at the muzzle, and cuts off (by the property of the parabola), OA on the axis equal to the abscissa OK.

$$\therefore \; MC = MB.$$

Again,

$$\frac{BC}{AB} = \frac{\pi \times \text{calibre}}{\text{number of calibres} \times \text{calibre}} = \frac{\pi}{\text{number of calibres}}$$

$$\text{in this case} = \frac{3{\cdot}14159}{45},$$

$$\text{but } AB \text{ given length to be rifled is } 107{\cdot}5\,;$$

$$\therefore \; BC = \frac{3{\cdot}14159 \times 107{\cdot}5}{45} = 7{\cdot}5\,;$$

$$\therefore \; MC \left(= \frac{BC}{2} \right) = 3{\cdot}75.$$

Having thus obtained the abscissa or X corresponding to the given co-ordinate OM, we can find the abscissa at any other measured distance on OM, and hence any number of points in OC.

For, according to the equation of the parabola,

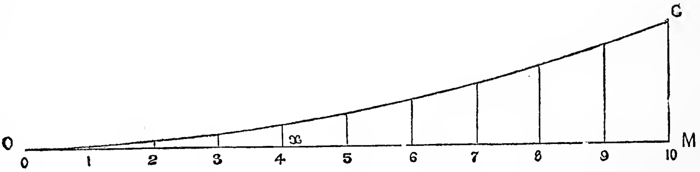
$$\frac{y^2}{x} = p \text{ which is true for all points};$$

$$\therefore \; \frac{OM^2}{MC} = p\,;$$

$$\therefore \; \frac{y^2}{x} = \frac{OM^2}{MC}\,;$$

$$\therefore \; x = \frac{MC \times y^2}{OM^2}.$$

A practical way to get the curve, is to divide the distance OM into any number of equal parts, say ten—



then the height x corresponding to any division, the 4th for example, is obtained thus :—

$$\frac{x}{4^2} = \frac{MC}{10^2} = \frac{3{\cdot}75}{100}\,;$$

$$\therefore \; x = \frac{3{\cdot}75 \times 16}{100} = {\cdot}6.$$

A steel bar, cast for the purpose, is then placed with one end resting on a plane table, and the other end supported at a height from the table equal to *MC*, and by means of the various measurements the curve is traced on it, and afterwards planed or slotted out.

If the pinion on the sliding rack and the bore of the gun are of the same diameter, the curves of the grooves and of the copying bar are the same; but if, as is generally the case (for, excepting the copying part, the same machine answers for all calibres and systems), the pinion and bore are different sizes, the curvature of the bar will differ proportionately from that of the grooves. Thus, if the pinion is half the size of the bore, the bar must have half the curvature of the grooves.

The cut is made when the boring bar is coming out of the gun, a stout rim of bristles on the head brushing out the chips before it. The cutter can be let in or out as required by means of a spindle which passes through the rifling bar, and it is kept up to its work by a weighted lever connected with the spindle.

All the grooves in the gun are first cut out roughly in succession, and then finely. The distance between the grooves is regulated by a disc fixed to the breech of the gun, and having its periphery equally divided by as many notches as there are to be grooves. The gun is fixed each time by a pall, and when a new groove has to be cut, is turned round to the next notch.

The groove is of the "Woolwich" shape, 1″·5 wide and 0″·18 deep, with concave edges. It is the same width for all natures, but it is a little deeper for the 10 and 12-inch guns. The number of course varies with the calibre, 7-inch guns having three, 8-inch four, 9-inch six, 10-inch seven, and 12-inch nine.

As a rule, about two calibres in length is left plain or unrifled for a powder chamber. The exact proportion is not fixed. The unrifled part, however, should be no shorter than actually necessary to prevent a detrimental air space between the smallest charge used and the base of the projectile, as the grooving tends to weaken the barrel very much, and the seat of the charge should be the strongest part of the gun.

(9) Previous to the 23rd January, 1868, rifled M.L. guns were left altogether unvented until after proof, at which they were fired by means of electric wires passed in at the muzzle. Since that date, all guns are drilled and tapped before proof, and fired through a removable steel vent, which is unscrewed after proof and replaced by the permanent vent; the object of this is to prevent the proper vent being strained by the large proof charge.

Proof.

Before a gun is proved, gutta percha impressions are taken of the whole length of the bore in the four quarters. The gun is then proved with two rounds—the projectile being equal in weight to the service one, but flat-headed for 7-inch guns and upwards, in order that it may penetrate as little as possible into the butt, and the charge being 1¼th the weight of the battering or highest charge used in service. The gun is fired in the open by means of an Abel's electric tube, connected with a magneto-electric battery in a bomb-proof shed.

With the early rifled guns much larger charges were used at proof, and then service charges and a double-weighted shot were used for some time;

but this was found to strain the gun too much, and the Ordnance Select Committee thoroughly investigated the matter, and having obtained the particulars of proof of guns in France, Belgium, Holland, Austria, Spain, Saxony, Denmark, America, Wurtemberg, Bavaria, and Sweden, came to the conclusion that the proof should be based on the highest charge which the gun will have to bear on service, and recommended the present proportionate charge for rifled M.L. guns, which was approved 13th July, 1864.

After proof, water is force-pumped into the bore, with the pressure of 120 lbs. to the square inch. This was instituted for guns with wrought-iron barrels to ascertain that the breech was perfectly closed, and is still continued in the case of solid-ended steel barrels, to make sure that the end has not been split in proof. After this the gun is cleaned, and gutta percha impressions of the bore being taken as before, the two sets of impressions are compared, to ascertain that no flaw of a serious character has been developed by proof. If any defect appears of which there is even the slightest doubt, the gun is subjected to five more rounds with service charges, and if after that the flaw does not appear to have increased, the gun is passed.

Processes after Proof and before Issue.

(1) Lapping.
(2) Obtaining preponderance and weight.
(3) Lining.
(4) Sighting.
(5) Venting.
(6) Marking, and the "marks" denoting pattern.
(7) Fixing on elevating plates and small fittings, sloping sides of cascable, and scoring breech.
(8) Painting and lacquering, and final inspection.

All the above processes except the last are performed in the one workshop (the sighting room), and generally, but not necessarily, in the exact order given.

(1) Every gun is LAPPED after proof, for the purpose of removing any little burs which may be thrown up on the edges of the grooves by the impetuous proof rounds.

(2) The meaning of the term "preponderance" as applied to modern guns, is the pressure which the breech portion of the gun, when horizontal, exerts on the elevating arrangement.

To ascertain the *preponderance*, the gun is supported at the trunnions by steel bars placed beneath them, and is brought horizontal by means of long handspikes in the bore. A Kitchen's weighing machine (like that ordinarily used at railways for weighing luggage), is then placed under the breech, and a block of wood is fixed on it, touching the gun underneath midway between the elevating points. The handspikes being then removed from the bore, the pressure on the block is indicated on the arm of the machine, and is the preponderance of the gun.

The preponderance of heavy guns should be as small as possible, so as not to interfere with the easy action of the elevating arrangement. 5 cwt. was assigned for 9-inch guns, and between 5 and 6 cwt. for the heavier guns; but by a recent order, 13th April 1869, all sea-service guns of 18 tons and upwards are to have no preponderance, and as this is practically impossible, it is further stated that anything under 3 cwt. will be considered as none.

The actual *weight* of each gun is taken by means of a strong steelyard, to the short arm of which the gun is slung by the trunnions.

(3) The object of LINING is to enable us to adjust the sights and elevating plates. The line of metal is the first line required, and is obtained as in cast-iron guns, by finding the axis of the gun and a line parallel to it along the top of the gun, but the process is much more refined and accurate. The gun is placed on a horizontal iron table, and being levelled across the trunnions and along the bore, is carefully scotched up. Instead of using a wooden batten to find the *axis*, a centering block, capable of being pressed out so as to fit tightly in the bore, is pushed home to the breech end. From the very centre of this block, a silk thread is extended through a plate on the muzzle to an iron upright (plumbed) stand, some feet in front of the gun. The stand is then moved to the right or left until the thread grazes the centre point on the muzzle plate.

A "breech gauge," provided with a vertical slide, having been fixed horizontally on the cascable, another silk thread is stretched from the stand to the breech slide so as to pass through a point in the muzzle plate in the same vertical plane as the lower thread, and just high enough to clear the breech of the gun. This gives the position of the *line of metal*, which is accordingly marked for about 1½ inch in length at the extreme end of the cylindrical part of the breech.

Vertical and horizontal lines are marked on the face of the muzzle along the slots in the plate, and short horizontal lines are marked on the right side of the muzzle, and on both sides of the breech, by means of a scribing block, the movable arm of which was adjusted to the horizontal slot, the block resting on the table.

The horizontal and vertical axes are cut, as usual, on the right trunnion.

(4) M.L. guns are SIGHTED like B.L. guns on both sides, and with the same kind of tangent sights; but M.L. guns have in addition short centre, hind, and fore sights. They have therefore three pairs of sights attached to the gun, and besides these there is a wood scale for use on board ship.

The tangent scale has a flat steel bar, graduated on three sides, viz. on one of its narrow sides in degrees, on the other in yards, and on one of its flat sides in tenths of inch of fuze corresponding to the range scale.

For guns with less than 40 inches radius, the tangent bar is equally divided for degrees; but for those natures with a longer radius, the 9-inch for example, the degree divisions regularly increase from 1° upwards.

Each degree is graduated into six divisions of ten minutes each. For a smaller number of minutes than ten, there is a screw collar on the *land service* pattern, which can he turned round until the required number is in line with a *fleur-de-lis* marked on the sight; this was considered unnecessary by the naval authorities, "as the tangent bar can be set to eye to within 2′ or 3′, which corresponds to about 16 or 24 yards of range—an insignificant quantity when compared with unavoidable errors arising from other sources." But in all other respects the L.S. and S.S. tangent sights are identical.

The range scale is marked in hundred of yards corresponding to full charges, and must be found most useful in active service, as the enemy's distance being known, it is only necessary to elevate directly and bore the fuze for the corresponding range.

The nature of the gun is also marked on the sight bar, otherwise the wrong sight might be used—for the bars are the same in section for all natures.

At the top of the bar is a gun-metal cross-head, at an angle complemental to the deflection, in order that it may be horizontal when in the gun. In the cross-head is a sliding leaf with a side motion, for the purpose of giving a regular allowance for wind blowing across the range, one wheel being higher than another, &c. The barrel head on the old pattern answered the same purpose, but the new pattern is simpler and cheaper, and not as liable to get out of order.

The tangent scales are set at the required elevation by means of a gun-metal movable clamp, which admits of the sight being taken to the light for the purpose.

The centre hind sight—a short scale for use at close quarters and moderate ranges—is of gun-metal. It is six sided; one of its sides has a degree scale, the other sides are marked with range and fuze scales for full and battering charges in all cases of guns for which there is sufficient data. It works in a gun-metal socket, fixed in the gun and provided with a set screw.

The trunnion sights, as also the centre fore sights, are known as the "drop" pattern, which consists of a pillar, collar, and socket of gun-metal, a leaf of steel, and screw for fixing the leaf. The socket is permanently fixed in the gun, and the pillar and collar each lock into it with a bayonet joint; so that when once the sight is in its true position, it cannot be removed without first raising the collar and turning the pillar round a quarter of a circle.

The advantages of the "drop" over the "screw" pattern (used in field guns), is that the former can be easily removed for transit, and afterwards replaced in its true position without any trouble.

The exposed gun-metal portions of all the tangent and drop sights are protected from the influence of the atmosphere by "BRONZING," the mixture of which consists of—

Bichloride of platinum (Pt, Cl_2)..............	2 parts
Corrosive sublimate (Hg, Cl)..................	1 "
Vinegar......................	1 "

The steel bar, leaf, &c. are "blued" for the same reason. This is easily effected by polishing the surface of the article, and heating it in a sand bath until it assumes a blue color, and then allowing it to cool naturally.

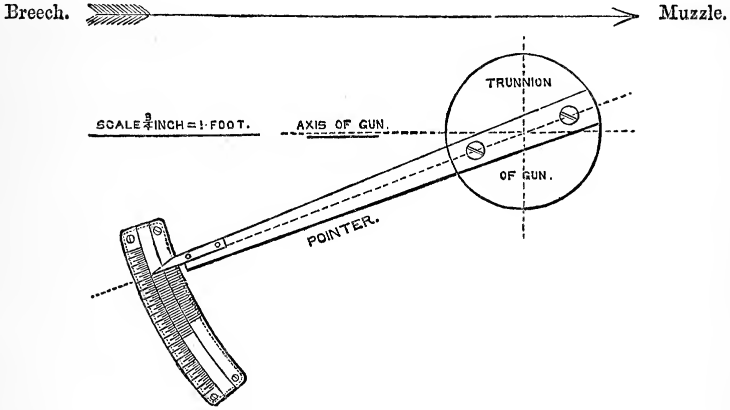
In naval service a *wood scale* is used in connection with the ship's pendulum, for giving elevation or depression when the object aimed at cannot be seen from the gun. The scale is square in section, and is graduated for degrees and for yards, both for full and battering charges.

When it arrives on board, it is cut so that when placed upright on the naval slide, the zero of the scale corresponds to the zero of the graduations (3½° elevation or depression), on the rear face of the cascable, the gun being parallel to the deck. It is provided with a movable slide, fitted with a pointer and clamping screw; this can be set at the required elevation or depression, and must coincide with the degree on the cascable which corresponds with the heel of the ship (see Changes in Patterns, §§ 1477–8).

The graduations on this scale are computed with a radius equal to distance between the rear face of cascable and the axis of the trunnions.

Turret guns were laid in a similar manner, but the allowance for heel was obtained, not from a ship's pendulum, but from the number of degrees necessary to raise a special tangent sight working on the top of turret so that it should be in line with the object, and with a fore sight which is fixed in the centre of the roof.

The direction of the object and the heel of the vessel are still obtained by the sights on the top of the turret, but the elevation is given (see List of Changes, 1st January, 1869), by means of a *pointer*, screwed to one of the trunnions, and working on an arc in rear attached to the cheek of the carriage. This arc is graduated with scale of degrees, yards, and fuze.



Graduated Arc.

In order to compensate for the *deflection* of the projectile to the right, caused by the right-handed rifling, the tangent sight must be inclined to the left. This inclination, which is called "the permanent angle of deflection," happens to be the same for all the B.L. series, but it varies for the M.L. natures according to the systems on which they are rifled.

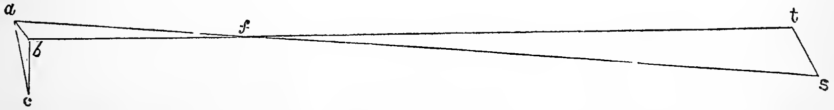
When a new nature of gun is about to be introduced, the permanent angle is calculated from actual practice at Shoeburyness with the specimen gun sent there on trial for range and accuracy. The gun is not sighted, but elevation is given by temporary means. A fine day being chosen for the practice, several rounds are fired with various elevations, and the angle is calculated for each round. The mean of the angles so obtained is adopted as the permanent angle of deflection.

The formula used for determining the angle for each round is

$$\tan\theta = \frac{\text{deflection}}{\text{range}} \times \text{cot elevation},$$

which is proved as follows:—

Let *bt* represent the line of sight, the gun being laid straight on the target *t*, and let *ts* be the deflection of the shot; now, the line drawn from *s*[*]



through fore-sight *f*, will give us the point *a* at which the head of the

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[*] This figure is drawn out of actual proportion, that it may be a convenient size.

tangent sight bc should be inclined to the left so that the gun may be laid at the distance ts to the left of the target; having ab we shall get the required angle acb. From similar triangles,

$$\frac{ft}{ts} = \frac{bf}{ab};$$

but bc being the length of the tangent scale, and bf its radius,

$$bf = bc \times \text{cot elevation.}$$

Again,

$$ab = bc \text{ tangent } acb,$$

$$\therefore \frac{ft}{ts} = \frac{\text{cot elevation}}{\tan acb};$$

$$\therefore \tan acb = \frac{ts \text{ cot elevation}}{ft};$$

but as $\angle\ acb$ is θ, ts the deflection, and ft the range, we may write the equation as above,

$$\tan\theta = \frac{\text{deflection}}{\text{range}} \times \text{cot elevation.*}$$

For SIGHTING, the gun is placed under the drilling machine, and being previously levelled to have the breech gauge and muzzle plate adjusted to it, is turned over on its right side to the required angle of deflection, as shewn by an angular level on the trunnion. Two silk threads are stretched at one side of the gun, from the breech gauge to the muzzle plate, parallel to each other, and at the width of the socket apart. The distance of the tangent sight socket being then measured from the breech gauge, the arm of the machine is brought over the spot, and the hole is drilled. The threads are next fixed on the other side, and the hole is drilled.

The hole for the centre hind sight is drilled in a similar manner. The sockets are then fitted in, and fixed by side screws. After this, the holes for the trunnion sights are drilled in the same way; but as they are not to be inclined at an angle, the gun must be previously re-levelled. The trunnion sight sockets are fixed in the bottom of the holes, and the sights "dropped" over them. Up to this stage the leaf of the trunnion sight is rough, and to obtain the proper position of the apex, a dummy tangent sight is put in the gun, and a silk thread is stretched through its notch from the breech gauge to the muzzle plate. The leaf of the trunnion sight is then filed down to gauge in the "hog-backed" shape, and the back slope is combed or roughed, so as not to reflect the light to the gunner's eye when laying the gun.

(5) *The vent* in rifled M.L. guns does not enter near the end of the bore as in S.B. guns, but at a point $\frac{2}{5}$ths the length of the service cartridge from the end, for it has been proved by experiment that by igniting the cartridge at this point, the maximum initial velocity is obtained.

Up to 1st November, 1868, the vent bushes were the ordinary copper cone vents, let in perpendicularly, but at that date a new kind of vent (proposed by Major Palliser) was inserted in the 10-inch guns. This vent consisted of a steel bush, lined with copper, screwed in from the exterior, against a platinum tip screwed up from the interior, the tip having a flange

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* This neat formula is due to Captain R. W. Haig, R.A.

or button-shaped head projecting into the bore to close the joint; and instead of entering the bore vertically, it was fixed upon the side* of the gun at an angle of 45° to the vertical axis, in order that it might be more easily served (see List of Changes, 1st December, 1868). It was subsequently decided (25th November, 1868), that all wrought-iron guns of 7-inch calibre and upwards should have similar vents (Fig. 1), but let in vertically as before, except in the case of guns of 10-inch calibre and upwards, whose size would render the vertical position awkward.

This was acted on for a short time, but the vents not proving satisfactory, the employment of the platinum tip was suspended, and steel vents lined with copper (Fig. 2), were used; but as these too did not answer expectations, all the big guns are now vented with copper specially hardened, the letter *H* being stamped on the top to indicate the fact.†

Fig 1.

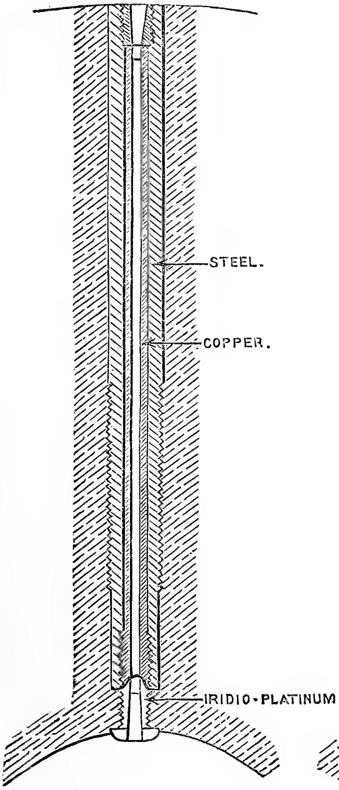
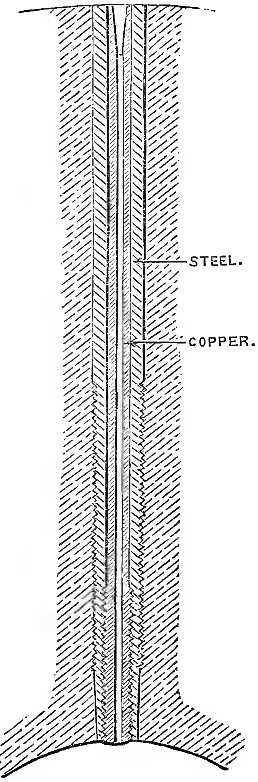


Fig. 2.



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* The vent is on the right side of the gun if intended for broadside purposes, but if for a turret gun, the vent is placed on the right or left hand side as convenience demands.

† The copper is 2 inches square in section. It is drawn down square while cold, under a light steam hammer, to the size required for the screw—the blows being as light and numerous as possible, so that the greatest amount of condensation may be effected. It is afterwards treated in the usual manner—*i.e.*, having a seven-thread screw, and coned at the bottom. In 10-inch guns and upwards, the threads are limited to a length of 6 inches above the cone, the upper part being plain.

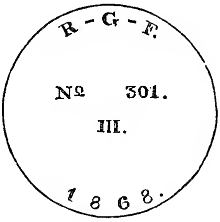
The matter, however, is not yet settled; platinum-tipped vents, without the flange, are under trial. The more powerful the gun, the greater is the wear and tear on the vent. Simple copper vents are most satisfactory for guns up to a certain size, and in spite of the softness of this metal, many think it will answer for very large guns quite as well as a more costly material. Indeed the difference in the expense of the various kinds of vents used is remarkable.

	£	s.	d.
A 9-inch vent of copper costs	0	6	3
" " steel, lined with copper	3	18	0
" " " " and tipped with platinum	16	4	0

This difficulty about vents is only one of the many which have to be overcome before we can obtain heavy guns perfect in every respect.

(6) In addition to the *marks* made in lining, and the Royal cypher before mentioned, the broad arrow and actual weight are stamped behind the vent, and two parallel lines are cut across the vent field to indicate the unrifled space. The material of the inner barrel (for example FIRTH'S STEEL), is stamped on the face of the muzzle, as is also the number of the steel barrel as entered in the registry of manufacture.

On the left trunnion are—



the initials R.G.F., the register number of the gun, the numeral signifying its pattern, and the year of proof. The register number is that by which the gun is registered in the Department records; it indicates also the number of that nature manufactured. With respect to the numeral, the word "pattern" was superseded by "mark," and the construction of guns has been designated as follows since 20th April, 1868:—

		Mark.	
9-inch	Original construction, to be	I.	Plate 2.
	F, with steel tube and breech-piece	II.	
	F II. " without breech-piece	III.	
8-inch	Original construction	I.	Plate 4.
7-inch of 7 tons.	F I. with breech-piece	II.	
" 6½ "	F II.	III.	
64-prs.	Original construction	I.	Plate 1.
	B pattern	II.	
	D "	III.	

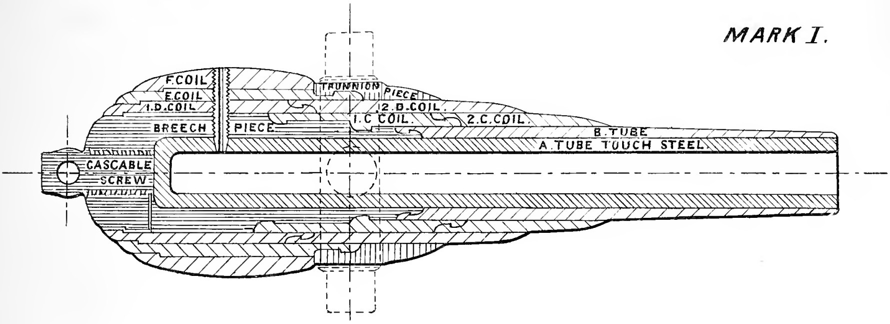
Guns of Mark II. construction are not numerous, there being only twenty-six 9-inch, six 8-inch, two 7-inch of 7 tons, twenty 7-inch of 6½ tons, and fifty 64-prs.; and all these, with the exception of the 9-inch, were made

ROYAL GUN FACTORIES.

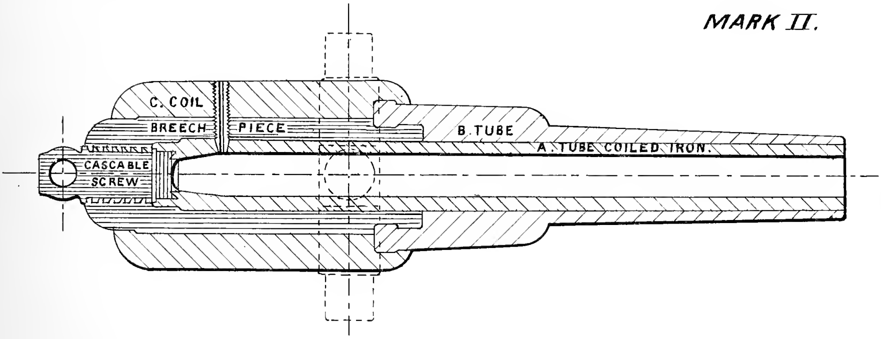
ORDNANCE WRO.T IRON MUZZLE LOADING GUN 7 INCH 6½ TONS R.

(*Scale. 3/8 Inch = 1 Foot.*
For general outline.)

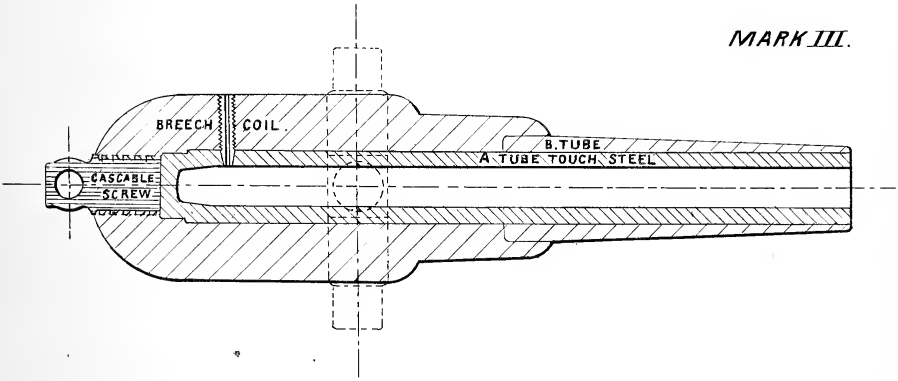
MARK I.



MARK II.



MARK III.



Lithographed at the Royal Artillery Institution

with coiled iron barrels, as steel was not then finally adopted as the material for inner barrels. Any of them however (except 64-prs.), which have since been re-tubed, have solid-ended steel barrels, as indicated on the face of the muzzle.

It was not thought necessary to alter the marking on guns made previous to the above date, so the letters F, F I., B, D &c., as above, will be found on the left trunnion instead of the numerals.

It will be observed that Mark III. indicates the same construction for 7-inch, 8-inch, and 9-inch guns. There however it ends; 10-inch guns of the same construction, being the first of that nature introduced, are Mark I., whilst the 12-inch are Mark II.

(7) *The extra fittings* or appurtenances of M.L. guns are very few and simple when compared with those for B.L. ordnance. They are limited to gun-metal elevating plates for guns for both services, guide-plates and friction tube pins for sea service, and muzzle studs and shot bearers for land service.

The position of the *gun-metal plates* for the elevating racks being measured from the "lines" already marked on the gun, and the holes being drilled and tapped by hand, the plates are firmly attached to the gun by means of a screw at each corner. They are also marked with the number of gun to which they have been adjusted. *The friction tube pin* is screwed in 1·3 inch to the left front of the vent, and a spare hole is made adjoining it, lest the pin should be broken off and leave its stump in the first hole. The leather loop of the S.S. quill friction tube is placed over this pin, to prevent the tube coming out when the lanyard is pulled, whilst to ensure direct action, the lanyard is passed through the *guide-plate,* which is screwed into the gun in rear.

A pulley arrangement is used for loading heavy guns in the naval service; so *shot bearers,* and *studs* to rest them on, are only required for L.S. guns.

There are, however, *preserving screws* for both services, as every gun is drilled for all the fittings, both L.S. and S.S., in order that it may be available for either service should occasion require. Thus a L.S. gun is drilled and tapped for the guide-plate and friction tube pin, and then the holes are stopped with preserving screws;* similarly, a S.S. gun is prepared for muzzle studs, although the holes are immediately afterwards stopped up again.

To bring the *cascable* to the approved shape, its sides are sloped towards the rear.

To prevent the handspikes slipping when working the gun, the breech is *scored* underneath at each side.

(8) The exterior of the gun being well cleaned, receives one coat of "Pulford's magnetic *paint,*" which is now used for all iron guns instead of anti-corrosion, to which it is superior in point of cheapness and durability. The bore receives one coat of the usual *lacquer.*

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* The preserving screws in the friction tube pin holes answer the purpose also of indicating the position of the vent by the touch, during night firing.

Finally. The gun and all its fittings having been inspected, and found in exact accordance with the sealed pattern, is issued for service.

Marked progress in Heavy Artillery during the last five years.

In conclusion, I would remark that the tests and trials bearing on this question, while exemplifying the pains taken to obtain the best war *matériel,* cannot fail to satisfy the most sceptical that the present construction of our heavy guns is sound and durable, and the general result must be gratifying to the authorities who approved of the system five years ago.

Indeed the past lustrum must always be a marked epoch in the history of our heavy artillery; for 7-inch, 8-inch, 9-inch, 10-inch and 12-inch guns have been made in numbers, and the system is applicable to still larger guns—nay, tracings have been actually furnished of 700-prs. of 35 tons, 800-prs. of 40 tons, and 1000-prs. of 50 tons, and the guns can be manufactured whenever the Secretary of State for War thinks fit to order them.*

But this progress in the production of heavy ordnance cannot be fully appreciated unless the difficulty of perfecting a more powerful gun than previously existed is properly considered and understood. In the first place, the practicability of manufacture and the durability of structure must be ascertained. The weight, calibre, length, system of rifling, weight and shape of projectile, &c. &c., must be all scientifically calculated so as to ensure excellence in range, accuracy, and penetration; and then each and all of these constructional details are liable to alteration should the thorough trial of a specimen gun at Shoeburyness render any amendment advisable. The sights too must be made, graduated, and adjusted, and finally the gun has to be vented—no easy task in the higher natures, as already observed.

Mr. Reed, Chief Constructor of the Navy, maintains that corresponding progress has been made in our ship building:—

> "It is but five years ago that Parliament was discussing the practicability of carrying 6½ ton guns at sea, especially in broadside ships; we have now 12 ton guns fought at sea with perfect ease, in many of the broadside ships of the Mediterranean and Channel squadrons, and the *Hercules* has long been cruising about, both at home and abroad, with 18 ton guns worked most satisfactorily at the broadside in ports 11 feet above the sea, and with a horizontal range of fire which no unarmoured ship's broadside guns possess. The *Monarch* has cruised successfully in heavy weather with 25 ton guns mounted in turrets. None but those who are hopelessly prejudiced can now doubt that, whether they be placed in turrets or out of turrets, the largest guns can be worked successfully with terrible effect at sea, and in heavier weather than the small guns of old could be fought."†

Surveying the whole question, therefore, by the calm light of facts and figures, I think it may fairly be asserted that, up to the present at least, England has not lost her naval supremacy.

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* 6000 tons weight of guns of various calibres could be made in the Royal Gun Factories in one year. A good way of calculating the time necessary for the manufacture of one gun, supposing the work to be continued without interruption, is to allow a week for each inch of calibre—*e.g.*, seven weeks for a 7-inch gun, nine for a 9-inch, and so on.

† "Our Iron-clad Ships."—1869.

THE MOBILITY OF FIELD ARTILLERY;

PAST AND PRESENT.

BY LIEUT. H. W. L. HIME, R.A.

[No. I.]

> "Le premier mérite de l'artillerie, après la bravourie des canoniers et la justesse du tir, c'est la mobilité."—*Marmont.* "*Esprit des Institutions Militaires.*"

Motion is the essential difference between the two great branches of the artillery service,[1] being as necessarily included in the conception of field artillery as it is necessarily excluded from the notion of garrison artillery. The latter is the artillery of rest, the former is the artillery of motion, and an immovable field artillery is a contradiction in terms. Placed in a given position in a given work, garrison guns are as irrevocably fixed as the work itself, and their fire is the one important point to which our attention is exclusively directed. Field guns, on the other hand, must share in the movements of the army of which they form part, whether on the march or in action, whether advancing or retiring, whether pressing a pursuit or covering a retreat; and in using them we have to consider not only their fire, but the position from which their fire is delivered.[2]

The advantages which a good position confers on field artillery, whether acting offensively or defensively, are twofold. Firstly, it increases many times the physical effect of the guns, while experience shows that it magnifies their moral effect to an extent which it would be impossible to predict before the event, and difficult to explain after it. Secondly, it diminishes in a surprising degree the loss arising from an enemy's fire, and it may secure the battery against a *coup de main.* The following examples will show that I do not over-estimate the value of a good position:—

At the combat of Golymin, 1806, Captain Chopin, by skilfully placing two guns and a howitzer—the only French guns that could be got into action—behind a trivial rise of ground, was enabled to keep at bay a large force of

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[1] "Field Artillery Tactics," p. 1. New York, 1864—the American field artillery drill book.

[2] "Bulletin des Sciences Militaires," Tom. II. p. 250. Thiroux, "Instruction de l'Artillerie," p. 365. Grewenitz, "Traite de l'Org. et de la Tact. de l'Art." p. 155. Favé, "Hist. et Tact. des Trois Armes," p. 404.

the enemy.[1] Two Prussian guns were so judiciously posted by M. Decker at Eylau, 1809, that though opposed to the fire of a French battery of 12-prs., they lost but one horse, while the French had five wagons blown up and several guns dismounted.[2]

At Quatre Bras, Lieut. Speckman's division of Major Kuhlman's troop of horse artillery, K.G.L., was so posted as to sweep a road along which a body of French Cuirassiers were advancing. The flanks of the guns were secure, and the hard roadway was well adapted for a fire of case. "As the Cuirassiers approached * * * * a remarkably well-directed fire was opened upon them" (by the two guns); "in an instant the whole mass appeared in irretrievable confusion; the road was literally strewed with corses of these steel-clad warriors and their gallant steeds; and Kellerman himself was dismounted and compelled, like many of his followers, to retire on foot."[3]

Piré's two horse artillery guns at Waterloo caused more annoyance, and indeed loss, to the British right, than whole batteries less happily placed.[4]

The main road at Montebello, 1859, was held by a division of an Austrian battery, under the command of Lieut. Prokesch, against the determined attacks of the French infantry. The ground was favourable, his flanks were secure, and the French advanced again and again, only to be repulsed.[5]

To such an extent is the physical effect of guns increased by well-chosen ground, and to a proportionate extent is the destructive effect of an enemy's fire diminished. A Prussian gun, skilfully run forward to the brink of a sunken road, did not lose a man during the battle of Paris, 1814; yet three other guns of the same battery, which forfeited the advantages of the position by being about forty paces in rear of the first, lost nine men, seven horses, a limber, and an ammunition wagon.[6]

At Ligny, a well-posted Prussian battery lost but three men during three hours exposure to the French fire.[7]

The moral advantages of a good position are incalculable and inexplicable.

At the affair of Newburn, 1640, a Scotch battery of leather guns, whose destructive effect must have been contemptible, caused such consternation in the English army by a few rounds from a good and unexpected position—"some thought it magic, and all were put in such disorder that the whole army did run with so much precipitation, that Sir Thomas Fairfax, who had a command in it, did not stick to own that 'till he crossed the Tees his legs trembled under him."[8]

Sir Ralph Hopton brought up his whole force of artillery—two small minion drakes, masked by cavalry—to a "convenient distance" from the enemy at the battle of Braddock-down, 1643. The position was excellent, and the movement so admirably carried out, that "after two shots from those drakes

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[1] "Mémoire sur le Gén. Senarmont," par le Gén. Marion, p. 22.

[2] Colonel Jervis, R.A., "Manual of Field Operations," p. 114.

[3] Siborne's "Hist. of the Waterloo Campaign," Vol. I. p. 144.

[4] Ibid. Vol. II. p. 88.

[5] "Study of the Italian Campaign," by Colonel Miller, R.A., p. 224.

[6] Decker's "Artillerie à cheval avec la Cavalerie," p. 107.

[7] Ibid.

[8] Bishop Burnet's "Hist. of My Own Times;" Book I.

(which not being discerned, and doing some execution, struck a terror into them)," he advanced, routed the enemy, and took five guns.[1]

The destructive effect of Turner's guns on the knoll at the Alma could not have been considerable, from the comparatively short time they were in action; yet so great was the terror their presence, on a commanding position, inspired in the Russian ranks, that these two 9-prs., by a short and rapid fire, "enforced the withdrawal of the causeway batteries, laid open the entry of the pass, shattered the enemy's reserves, stopped the onward march of the Ouglitz battalions, and chained up the high-mettled Vladimir, in the midst of its triumphant advance."[2]

Facts such as these force upon us the conclusion that bad guns well placed are more effective than good guns badly placed.

To avail themselves of the advantages of good positions, batteries must possess mobility—the capacity of moving, accompanied by their gunners and an adequate supply of ammunition, from point to point of a battle-field. It is surely unnecessary to insist upon this definition of mobility; for it must be evident, on a moment's consideration, that to move a body of field artillery to any purpose, it must be moved as a whole, *totus teres atque rotundus* —guns, gunners, and ammunition. To move it otherwise is to put asunder things which should ever remain joined together; to dislocate the parts of a complicated machine which can only act in combination. Infantry without their rifles, cavalry without their sabres, present a no more forlorn spectacle than gunners without their guns. And what are guns without their gunners? —the bow without the archer, the compass without the magnet, the body without the soul.

The limits of mobility are clear and definite. It is a fundamental axiom in field artillery tactics that *guns are useless when limbered-up*. From this axiom it follows: firstly, that the movements of a battery in action should be *minimum in number*[3]—because in order to manœuvre, the guns must be limbered-up; and secondly, that the movements of a battery in action should be made at *maximum speed*—because the slower the pace, the longer the guns remain limbered-up.

Efficacy of fire[4] and mobility, then, are the two grand attributes on whose development the efficiency of field artillery depends, and the relation between them is as intimate as that between the magnitude and direction of a force in mechanics. For we can no more estimate the capabilities of a battery of guns of given calibre, without knowing at what pace it can move into action with its gunners and ammunition complete, than we can calculate the effect of a statical force of given magnitude, if we happen to be ignorant of the

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[1] Lord Clarendon's "Hist. of the Great Rebellion," p. 366. The effect of two (or four) shots from minion drakes must have been paltry; and the secret of Sir Ralph's success undoubtedly lay in the suddenness of his fire, and the excellent position of his guns.

[2] Kinglake's "Hist. of the War in the Crimea," Vol. II. p. 400.

[3] The fault which detracts so much from the value of Decker's otherwise excellent work, "L'Artillerie à cheval avec la Cavalerie," is his constant neglect of this principle. The manner in which, in many cases, he handles his guns, would be more suitable to a squadron of cavalry than to a battery of artillery.

[4] The destruction inflicted upon an enemy is, of course, the measure of the efficacy of fire; and, for any given gun, in any given position, depends upon the precision with which the gun is laid, and the successful action of the ammunition.

direction in which it acts. So close, indeed, is their connexion, that the history of field artillery is little more than a record of a series of laborious and painful efforts, extending over centuries, to increase precision of fire and capacity of manœuvre; and since the origin and rise of the arm,[1] the attention and energies of those connected with it have been entirely absorbed, directly or indirectly, knowingly or unwittingly, in their development. Each successive step in the manufacture of gunpowder, each discovery in chemistry which contributed towards it, has not only directly improved the fire of field guns, but has indirectly increased their mobility; for the enormous charges of the weak, slow-burning powder of bygone times, necessitated a corresponding length of bore, and length of bore involved weight of metal. The progress of metallurgy, too, and every advance in the manufacture of ordnance, tended to produce the same results; for not only was accuracy of fire seriously affected by badly cast guns and round shot of irregular shape and unequal density, but within certain limits the weight of the gun diminished, and its mobility consequently increased, as the quality and strength of the metal improved. Every reform in the construction of carriages, in the organization of drivers, in the quality of the horses, and in the state of the harness, exerted a direct influence upon the mobility of the guns; and the accuracy and deadliness of their fire increased with the steadiness and intelligence of the gunners who worked them, and the goodness and durability of the ammunition. Thus every improvement that has been made, either in the *personnel* or *matériél* of field artillery, may be resolved into an improvement in its efficacy of fire, or in its mobility, or in both.

To indicate the principal of these successive improvements; to show that the state of field artillery was invariably most depressed when its mobility was most neglected, while its greatest successes were achieved under those leaders who knew best how to move it; to prove, in a word, that its progress chiefly consisted in the development of its mobility;[2] I shall now take a brief retrospect of the history of the arm.

Had the guns which Edward III. brought into the field at Creçy[3] produced an effect at all commensurate with the expense of constructing and working them,[4] and the labour of moving them, it is more than probable

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[1] The following passage may be found in a respectable book on Tactics, finished as late as the year 1810:—"Quoi qu'en disent certains auteurs, on ne saurait regarder l'artillerie, à proprement parler, comme une arme, car elle ne peut seule fixer la victoire."—Traité de Tactique, par le Marquis de Ternay, Tom. I. p. 251. According to this theory the English cavalry, the cavalry that charged at Salamanca, was not an arm during the Peninsular War, if we may rely upon a statement made by the Duke of Wellington to his Judge Advocate General:—"Our cavalry never gained a battle yet. When the infantry have beaten the French, then the cavalry, if they can act, make the whole complete, and do wonders; but they never yet beat the French themselves."—Larpent's Journal, Vol. II. p. 73.

[2] Favé, "Hist. et Tact. des Trois Armes," p. 293.

[3] "Les trois canons employés par les Anglais à Créçy ne peuvent être comparés qu' à trois de nos fusils actuels faisant une seule décharge."—Etudes sur le passé et l'avenir de l'Artillerie, par le Prince Napoleon-Louis Bonaparte, Tom. I. p. 42.

[4] Gunpowder "long remained a costly article; and even in the reign of Charles I. may be found complaints of its dearness, 'whereby the train-bands are much discouraged in their exercising.' *Parliament. History*, Vol. II. p. 665. In 1686, it appears from the *Clarendon Correspondence*, Vol. I. p. 413, that the wholesale price ranged from £2 10s. to £3 a barrel. On the price of making it in the present century, see Liebig and Kopp's *Reports on Chemistry*, Vol. III. p. 325. Lond.

that artillery would have at once received a large share of public attention in England, and would have shortly attained to as great a degree of perfection as the state of chemistry and metallurgy permitted. Cavalry had about this time exchanged their hauberks for plate-armour, which was proof against pointed swords, lance thrusts, and battle-axes, and cavalry charges were in consequence irresistible.[1] Any invention, therefore, which created a counterpoise to the overwhelming influence of men-at-arms, would have been gladly welcomed in the English army; for its chief strength lay then, as it has always lain, in its foot soldiers, in its archers, in its infantry,[2] and it was then engaged in a struggle with a nation which possessed a brave and numerous cavalry.[3] But the feebleness of the guns, the weakness of the powder, the danger attached to the service of the guns, the inaccuracy and slowness of their fire, and the difficulty of moving them from place to place, showed from the first how chimerical was the hope that the new arm could cope successfully with the men-at-arms. The effect it produced, however, was sufficient to ensure its retention in the English service, and its adoption in all others. It killed few, no doubt; but it terrified many. Its physical effect was small; but its moral effect was great, and "à la guerre tout est moral."[4] Indeed the essential difference between ancient and modern warfare, tactically considered, lies in the vast importance which the invention of gunpowder at once conferred upon moral force. Moral force had always exerted an influence, and occasionally a great influence, in war, but this "mischievous discovery"[5] heightened its importance in an extraordinary degree. The battles of ancient times were, in the majority of cases, of the Horatii and Curatii type. The hostile forces met, a prolonged and desperate struggle took place, physical strength prevailed, the weaker fell, and the battle ended. As surely as the greater of two forces predominates, if they act in the same straight line and in opposite directions; as surely as the heavier of the weights in a true balance turns the scale; so surely did brute force in olden times gain the advantage, and the number of dead on either side was an almost infallible test of victory or defeat. "Ajax beating down the Trojan leader with a rock which two ordinary men could scarcely lift; Horatius defending the bridge against an army; Richard, the Lion-hearted, spurring along the whole Saracen line without finding an enemy to stand his assault; Robert Bruce crushing with one blow the helmet and head of Sir Henry Bohun, in sight of the whole array of England and Scotland—such are the heroes of a dark age."[6] The mere possession of strength entitled a man to universal respect, and the story of Hercules was so popular that no less than forty vagabonds successfully assumed the character at different periods of the world's history.[7] But the race of blind force was run when gunpowder was discovered; the

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1852."—Buckle, "Hist. of Civilisation," Vol. I. p. 189, Note 44, Liepsig Ed. How many lbs. "a barrel" then contained, I do not know.

[1] Hallam's "Middle Ages," Vol. I. p. 265. Oxford English Prize Essays, Vol. II. pp. 120, 131.

[2] Hallam's "Middle Ages," Vol. I. p. 55.

[3] "Etudes sur le passé et l'avenir de l'Artillerie," par l'Empereur Napoleon III. p. 21.

[4] Pensées de Napoléon I. p. 230. Paris, 1863.

[5] Gibbon's "Decline and Fall of the Roman Empire," Vol. XI. p. 55.

[6] Macaulay's "Hist. of England," Vol. VII. p. 32.

[7] Smith's "Dict. of Biography and Mythology," art. Hercules.

chemical mixture which the monk[1] stumbled upon in the solitude of the cloisters, gave the victory to mind over matter in war; and the introduction of artillery gradually revolutionised tactics. The guns could be loaded but slowly, it is true, and few of the shots struck the mark; but when the fatal ball did enter the ranks of the enemy, death followed in its wake. No courage could avail against it, no armour was proof against it, and it acted from distances which the strongest archers were unable to reach. But it was not the destruction which it actually caused, it was the destruction which men felt it *might* cause, that constituted the chief element of its strength. The startling results which it produced so rapidly, so suddenly, so unexpectedly, acted upon their imaginations. The deafening noise of the discharge, the blinding smoke which accompanied it, wrought upon their fears.[2] The bravest blanched when he saw some splendid knight, some stalwart man-at-arms, whom it would have required long hours and overwhelming numbers to overcome and slaughter with battle-axes and maces, struck down as it were by a thunderbolt. If the last shot was destructive, the next shot would be equally destructive—it might be even more destructive. So argued the soldiery, and in such a manner did artillery, while in its infancy, exert its influence in battle. Beginning from such small beginnings, its importance slowly increased, its power gradually grew mightier, until at last the whole face of tactics was changed. It became no longer necessary for a leader to combine in himself the strength of Polyphemus with the stature of Goliath.[3] A decrepid Englishman[4] overran Spain in the 18th century; a Frenchman of diminutive figure conquered almost the whole of Europe in the 19th century. "At Landen," says Lord Macaulay, "two poor sickly beings, who, in a rude state of society would have been regarded as too puny to bear any part in combats, were the souls of two great armies. In some heathen countries they would have been exposed while infants. In Christendom they would, six hundred years earlier, have been sent to some quiet cloister. But their lot had fallen on a time when men had discovered that the strength of the muscles is far inferior in value to the strength of the mind. It is probable that, among the 120,000 soldiers who were marshalled round Neerwinden under all the standards of Western Europe, the two feeblest in body were the hunchbacked dwarf who urged forward the fiery

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[1] Roger Bacon. In ascribing the invention of gunpowder to an Englishman, I follow a French officer, Col. Favé. "Hist. et Tact. des Trois Armes," p. 8. Lord Byron remarks that although Friar Bacon discovered gunpowder, "he had the *humanity* not to record his discovery in intelligible language."—Don Juan, Canto 8, st. 33, note. It was known, however, half a century before Lord Byron wrote this sentence, that as the precision of fire-arms increases, the destruction of life in battle decreases. "This furious engine," says Hume, speaking of artillery, "tho' it seemed contrived for the destruction of mankind and the overthrow of empires, has, in the issue, rendered battles less bloody."—Hist. of England, Vol. II. p. 432 (published in 1754–1762).

[2] This is no mere fancy of mine. See Petrarch, "De Remediis Utriusque Fortunæ," in Jervis' "Manual of Field Operations," p. 61; Spenser's "Faerie Queen," Bk. I. Canto 8, st. 13; and a host of other such passages. As late as 1610, a French military writer says:—"Quelques-uns sont d'opinion que (l'artillerie n'est pas necessaire), d'autant qu'elle espouvante plus qu'elle ne tue."—Arsenal et Magasin d'Artillerie, p. 102. Adam Smith points out with great judgment the differences between ancient and modern warfare, in his "Wealth of Nations," Book V. ch. 1, p. 315, M'Culloch's Ed.

[3] Oxford English Prize Essays, Vol. II. p. 114.

[4] See Macaulay's Essay on Lord Mahon's Hist. of the Spanish War of Succession.

onset of France, and the asthmatic skeleton who covered the slow retreat of England."[1]

When artillery first came into use, then, its influence depended almost entirely upon the moral effect produced by its feeble fire, delivered invariably from the worst of positions,[2] which it was impossible to change during the course of an action. The great increase of physical power, the vast accession of moral power, which results from a good position, and the imperative necessity of adapting the position of guns to the changing fortunes of a battle-field, were then unknown; because war is an experimental science, and the experience of ages was required to prove the primary truth, so well expressed by Marshal Marmont—" le premier mérite de l'artillerie, après la bravourie des canoniers et la justesse du tir, c'est la mobilité."

Under ordinary circumstances, the accumulated military experience of half a century, at a period when wars were frequent,[3] ought seemingly to have sufficed to establish this principle as the foundation stone of field artillery tactics; but there were many counteracting forces in operation when the arm first appeared in the field, which rendered this impossible.

As early as the year 1139, the church, in the second General Council of the Lateran, forbade the use of military machines, as likely to cause unnecessary bloodshed.[4] Such a prohibition would avail naught in the 19th century; but the power of the church was so enormous in the middle ages,[5] that the expressed will of the clergy was all but irresistible, and the oath prescribed by the Germans as a safeguard against the use of machines in war, was probably a consequence of this decree. From the terms of this oath,[6] and the denunciations of the Chevalier Folard, centuries after, against the use of cannon in battle,[7] it would appear that, in common with other inventions, artillery was long looked on with suspicion, and that its introduction was regarded by some as a sign of that effeminacy and degeneracy which under the later emperors had made a large use of machines indispensable in the Roman armies.[8]

Metallurgy was in its infancy, chemistry did not exist, when artillery first appeared. The use of coal in the manufacture of iron was only

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[1] The English under William III. defeated by the French under Luxembourg, 1693. Macaulay's "History of England," Vol. VII. p. 33.

[2] That directly opposite the object fired at. "Il ne faut jamais placer d'abord les batteries vis-à-vis des points qu'on voudra battre."—De Ternay, "Traite de Tactique," Tom. I. p. 286.

[3] Buckle, "Hist of Civilisation," Vol. I. p. 175.

[4] Favé, p. 9. By a slip of the pen, Colonel Favé has given the date as 1140. Mosheim's "Ecclesiastical History," p. 427, Reid's Ed. This prohibition, like Alexander III.'s bull for the emancipation of slaves, was no doubt rather a pious exhortation than a law.

[5] "Those ages of darkness, or, as they have been well called, 'ages of faith.' Those, indeed, were golden days for the ecclesiastical profession, since the credulity of men had reached a height which seemed to insure to the clergy a long and universal dominion."—Buckle, Vol. II. p. 29, Leipsig Ed.

[6] By this oath men were bound to abstain from the use of inventions "pour la ruine ou la destruction des hommes, estimant ces actions autant injustes qu'elles sont indignes d'un homme de cœur et d'un veritable soldat."—Quoted from Favé, p. 9.

[7] In his edition of Polybius.

[8] "The use of military machines in the field became gradually more prevalent, in proportion as personal valour and military skill declined with the Roman Empire. When men were no longer found, their place was supplied by machines."—Gibbon's "Decline and fall of the Roman Empire," Vol. I. ch. 1.

tried for the first time by Dudley, in the reign of Charles I., and was not common for another century,[1] and the operation of puddling was not invented until 1781, by Mr. H. Cort. Chemistry, in the proper sense of the word, was unknown before the 17th century,[2] and the gunpowder of the 14th, 15th, and 16th centuries was scarcely more powerful than squib composition at the present day.[3] The progress of artillery might keep pace with that of metallurgy and chemistry, but it could not outstrip them. Their bounds were its bounds; so far could it go, but no further.

The amount of *matériél* necessary for the equipment of a given force of artillery is out of all proportion to the quantity required for a corresponding force of cavalry or infantry, and the disparity was as great in the 14th century as it is in the 19th. In the middle ages, when every peasant was master of a bow or sword,[4] and every gentleman possessed a horse and armour, it was easy to assemble at a moment's warning an army of knights and archers.[5] But artillery could form no part of these hasty levies. It is impossible to improvise this arm on a sudden emergency: the guns, the carriages, the ammunition, had, even in the rudest periods, to be constructed and guarded with care in time of peace, to enable them to appear on the field in time of war. Trained gunners, too, were indispensable, and time and experience were needed to educate them. Horsemanship, the use of the sword, and archery, might be acquired by private individuals, but a knowledge of gunnery was restricted to the few who had access to guns which, owing to the cost of acquiring them, can only belong to governments. In a word, whatever force of artillery it was considered desirable to employ in time of war, it was necessary to maintain in time of peace, and this acted prejudicially to the progress of the arm. For in an age when political economy and the science of finance were unknown, few rulers possessed a treasury capable of meeting the demands requisite for the construction and maintenance of an efficient force of artillery;[6] and further, the spirit of these times, and the nature of feudal obligations, were opposed to the existence of standing armies.[7]

The use of mercenaries also exercised an unfavourable influence on the artillery. Beginning with the "solidarii" of the 11th century,[8] and rapidly increasing during the next two hundred years, they were commonly employed in the 14th and 15th centuries. For these marauders, the live ass was better than the dead lion. A dead soldier, of whatever rank, was only worth his armour and sword, and what money might be found about him;

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[1] Review of the History of Iron, in the "Quarterly Review" for July, 1862.

[2] It may be gathered from the Latin oration delivered at Cambridge by Isaac Barrow in 1654 (Barrow's Works, Vol. IX. pp. 35–47), that chemistry was at this time "just emerging from its mystic or thaumaturgic stage into the light of science."—See the art. on Dr. Barrow in the "Quarterly Review" for Oct. 1869, pp. 359–360.

[3] Mr. H. Latham, in "Journal of United Service Institution," Vol. IX. No. 34.

[4] Buckle's "Hist. of Civilisation," Vol. I. p. 188.

[5] Eccleston's "English Antiquities," p. 62.

[6] For an account of Edward III.'s financial difficulties during the Créçy campaign, see Longman's "Life and Times of Edward III." Vol. I. pp. 116–153. Adam Smith's "Wealth of Nations," Book IV. ch. 1, p. 195, M'Culloch's Ed.

[7] Hallam's "Middle Ages," Vol. I. p. 262. Buckle's "Hist. of Civilisation," Vol. I. p. 190.

[8] Hallam's "Middle Ages," Vol. I. p. 264. Buckle's "Hist. of Civilisation," Vol. I. p. 191.

but from the wounded knight, or disabled burgess, who haply fell into their clutches, they could and would extract a heavy ransom. As a matter of course, therefore, they were violently opposed to the use of an arm which was no respecter of persons, and struck down the rich and the poor alike. To such a preposterous extent was this system carried, that at the battle of Zagonara, 1423, three men only were killed, and these three by suffocation in the mud into which, wearied by the exertion of fighting and the weight of their armour, they had fallen. At the battle of Molinella, 1467, no one was killed; and in an action between the Neapolitan and Papal troops in 1486, which lasted all day, no one was killed, and it is not recorded that any one was wounded.[1]

The simple character of battles, and the almost total absence of manœuvres, in the sense in which we now use the word, tended to seriously retard the mobility of field artillery, during the three first centuries of its existence. In these times, as a general rule, the hostile forces were drawn out exactly opposite each other; each army having its infantry in the centre, its cavalry on the flanks, and the guns distributed along the front, or on the flanks of the cavalry. A cannonade opened the action; the cavalry presently charged; the infantry whose cavalry were beaten in this charge retreated, pursued by the enemy;[2] and the guns, as a matter of course, fell into the hands of the victors.[3] The want of discipline and the want of drill rendered the manœuvring of these raw levies, except in the simplest way and under the most exceptional circumstances, impossible; and ordinary men could not be expected to detect the importance of mobility from the experience of battles in which mobility was scarcely necessary.

The very want of mobility, which was the effect of these causes, reacted and raised a prejudice against the use of the arm in the field. As late as the end of the 15th century, the presence of artillery with an army "was not very frequent; a circumstance which will surprise us less when we consider its unscientific construction, the slowness with which it could be loaded, its stone balls of uncertain aim and imperfect force, and especially the difficulty of removing it from place to place during an action."[4] Generals were not likely to encumber their armies with a large number of guns which, once placed, were immovable during the whole course of a battle.[5]

The experience in the field, therefore, which was needful to bring vividly before men's minds the importance of mobility, was in reality but small during the first three centuries of the existence of field artillery, and there was little or no means of recording such experience, and handing it down from one generation of artillerymen to another. The valuable lessons that each successive leader of artillery learned on the field of battle, perished with him;

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[1] Hallam's "Middle Ages," Vol. I. p. 477.

[2] Favé, "Hist. et Tact. des Trois Armes," p. 400.

[3] This was the fate of the artillery until Marlborough's time. "Jusqu' alors toute l'artillerie d'une armée battue tombait ordinairement au pouvoir des vainqueurs; mais dans cette bataille (Malplaquet, 1709), quoique l'artillerie des Francais eut continuée à jouer jusqu' à l'assaut des retranchemens, les vainqueurs ne prirent que huit à dix pièces."—Grewenitz, "Traité de l'Org. et de la Tact. de l'Artillerie," p. 61.

[4] Hallam's "Middle Ages," Vol. I. p. 480.

[5] Giustiniani's "Essai sur la Tactique," p. 216.

because in these times military history can hardly be said to have had an existence,[1] and plan-drawing—so necessary to the right understanding of even the simplest battle, so necessary for the study of the position and movements of artillery in action—is a comparatively recent invention. The battle-scenes of Homer and Livy are as intelligible and credible as those of most military historians previous to Marlborough's time, and their plans are inferior to their matter. Some notion may be formed of the state of military plan-drawing in England as late as the middle of the 17th century, from an inspection of the plan of the battle of Naseby, given in Sprigg's "Anglia Rediviva," a book published in London in 1647;[2] but it ought to be added that matters were in this respect somewhat better on the continent.

Retarded by the obstacles that I have enumerated—the opposition of the church, feeble as its resistance may have been; the backward state of chemistry and metallurgy; the impossibility of possessing an efficient train of artillery unless it be kept up as a standing force, and the difficulty of maintaining a standing force in feudal ages, before finance became a science, or political economy was known; the adverse influence of mercenaries; the rudimentary state of tactics; the reactionary prejudice against the arm, raised by its immobility; and the want of military history[3]—retarded by these obstacles, the artillery was at first either overlooked entirely, or regarded with contempt; and, under conditions so unfavourable, it was hopeless to expect that even professional artillerymen should dream of the possibility of such an attribute as mobility—for the discovery of Marshal Marmont's principle essentially depended upon experience, and the less the arm was valued, the less it was employed in the field.

In spite of all opposition, however, the "new artifice of evil"[4] gradually gained ground. The resistance offered to its progress was formidable; but nothing could stop its advance, for the force that propelled it was moral force, and "à la guerre les trois quarts sont des affaires morales. La balance des forces réeles n'est que pour un autre quart."[5] It moved forward; but its onward steps were laboured and slow, and wheeled gun-carriages were only introduced towards the close of the reign of Louis XI. of France, or the commencement of that of Charles VIII.[6] This important event forms the first great landmark in the history of field artillery, and from it dates the origin and rise of the mobility of the arm.

Guns could now move, and it might be supposed that their destructive effect and mobility advanced, after this signal epoch, at equal rates along parallel lines. But such was not the case. Charles VIII., Francis I., and

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[1] "Ce n'est guerre que sous François I., et sous l'Empereur Charles V., que les Italiens, les François, les Espagnols, et les Allemands ont commencé à écrire en détail sur la discipline militaire." Daniel, "Hist. de la Milice Française," Vol. I. p. 380.

[2] There is a copy of this book in the Library of the Royal Artillery at Woolwich.

[3] I do not assert that these retarding influences acted either simultaneously, or with equal intensity; but I maintain that they were all in action, at one time or other, and with more or less intensity, during the first three centuries of the existence of field artillery.

[4] Hallam's "Middle Ages," Vol. I. p. 480. Gibbon's "Decline and Fall of the Roman Empire," Vol. XI. p. 55.

[5] Napoleon's Correspondence. 1809.

[6] Favé's "Hist. et Tact. des Trois Armes," p. 12. Grewenitz' "Traite de l'Org. &c. de l'Art." p. 28.

Henry IV. of France, did great things with their artillery—especially the latter, who made a most masterly use of his guns, and manœuvred them as frequently and as rapidly as might be;[1] but the more carefully one studies the military history of the 14th, 15th, and 16th centuries, the more clearly one sees that the successive improvements of accuracy of fire were far more numerous and important than those of mobility. Nor is the matter incapable of explanation. The effect of fire was obvious to the thoughtless many; the value of mobility was only dimly imagined by the thoughtful few. Accuracy of fire stood forward with such striking prominence as to draw all eyes upon itself, to throw mobility into the cold shade, and to lead gunners to regard mere fire as the only attribute of their arm that was worthy of attention. Men were fascinated by the roar of the guns, and a century and a half rolled away after the introduction of wheeled carriages, before a man arose who had the genius to discern the supreme importance of mobility, and the power to break through the iron barriers which prejudice and dulness invariably erect to arrest the progress of new ideas.

Tedious and painful were the movements of the ordnance when the Thirty Years' War broke out, and the father of modern field artillery, Gustavus Adolphus, appeared at the head of an army.[2] His clear, piercing intellect soon perceived the immense disadvantages of his cumbrous field artillery, and he resolved to increase its mobility at all hazards. He was deaf to the argument which stupidity has ever at hand, that what has existed for ages—what has been handed down to us by our fathers, ought not rudely to be set aside. Change had no terrors for him; he was not a man to reject an improvement because it was an innovation; and he was unshackled by the perversity or obstructiveness of superiors, for he was a king. At a stroke, therefore, he introduced *leather guns*, of superior mobility, although of inferior precision, to the ordinary iron guns of the time; whilst, at the same time, he drew a broad line of demarcation between field and siege artillery, by remanding all guns of a greater calibre than 12-prs. to the latter branch.[3] These vigorous steps form the second great landmark in the history of field artillery.

The anticipations formed by the Swedish King of the advantages of increased mobility, gained even at the expense of efficacy of fire, were realised, and more than realised, at the battle of Leipsig, if there alone;[4] but with his premature death at Lützen, ended the brilliant career which he had opened for the artillery. As a gunner, he was far in advance of the times in which he lived, and when he was snatched away, there was none on whom his mantle could fitly descend. Like the poet Chaucer, Gustavus Adolphus

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[1] Colonel Favé gives a detailed sketch of the principal battles fought by Francis I. and Henry IV. in his admirable work.

[2] He had previously served in Poland and Russia. Schiller's "Hist. of the Thirty Years' War," Bohn's Ed. p. 86.

[3] Favé's "Hist. et Tact. des Trois Armes," p. 80.

[4] No one who has studied the battle of Leipsig carefully, can doubt the justness of the Emperor Napoleon's remarks on the tactics of Gustavus Adolphus, "*le nouveau César*:"—"Jamais avant lui on n'avait fait mouvoir les troupes avec autant de promptitude et d'habilete sur le champ de bataille, jamais on n'avait fait un emploi aussi judiceux de l'artillerie, et nous croyons que les écrivains militaires n'ont pas rendu à ces dispositions la justice qui leur est due."—Etudes sur le passé et l'avenir de l'Artillerie, Tom. I. p. 330.

was a bright and genial day in early spring, succeeded by the redoubled horrors of winter, when "those tender buds and early blossoms which were called forth by the transient gleam of temporary sunshine, are nipped by frosts and torn by tempests."[1]

Under the able direction of the king, the mobility of his light artillery far more than compensated for its enfeebled fire; but when he died, he was succeeded by mere military drudges, incapable alike of rising above everyday routine, or of grasping the idea of mobility. The staff of Goliath had fallen into the hands of an ordinary mortal. Those who came after Gustavus Adolphus were powerless to wield the leather guns; the leather guns fell into disuse; the importance of mobility was forgotten; and another century of darkness, illumined by only an occasional gleam of light, closed round the course of field artillery.

SHORNCLIFFE,
27th November, 1869.

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[1] Wharton's "History of English Poetry."

ON THE

ARRANGEMENT OF EXPENSE MAGAZINES, SHELL ROOMS, SMALL STORES, AND SIDE-ARM SHEDS

FOR

BATTERIES OF HEAVY RIFLED GUNS.*

[COMMUNICATED BY THE DIRECTOR GENERAL OF ORDNANCE.]

Introductory Remarks by Major-General Lefroy, R.A.

THE auxiliary batteries at Southsea Castle, Portsmouth, were so far completed as to be in a fit state to be handed over to the Royal Artillery in July, 1868, and it was proposed by the Department of Works to take advantage of this opportunity to ascertain whether any improvement could be suggested, as regards the accommodation and arrangement for the reception of ammunition and stores, and for the supply of ammunition to the guns, the objects kept in view in the construction were in general accordance with the recommendations of a Committee assembled at the War Office in July, 1866, for the purpose of agreeing on some general rules to be observed in these important arrangements, and which reported as follows:—

Proceedings of a Meeting assembled at 109 *Victoria Street, on the* 30*th July,* 1866.

PRESENT.

Major-General ST GEORGE, C.B., R.A.
Major-General A. G. TAYLOR, R.A.
Brig.-General LEFROY, R.A.
Colonel GAMBIER, C.B., R.A.
Lieut.-Col. JERVOIS, C.B., R.E.

"Major-General Taylor read some remarks he had drawn up as Inspector-General of Artillery, the result of his observations in making his inspections. These are appended to the proceedings.

"The meeting considered the general principles to be adopted in the future construction of forts and coast batteries, and decided on the following:—

1. "The Southsea auxiliary defences, as lately constructed, with respect to the arrangements of the magazines, expense magazines, shell rooms, &c., as

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* See Vol. II. p. 279, for a previous paper on this subject.

shewn in the plan of that work laid before the meeting, are generally approved, and may be taken as a satisfactory general guide for future constructions. (Plate I*).

2. "The expense magazines as shewn in this plan, viz. one for every four guns, is concurred in. Each magazine should contain at least twenty-five rounds per gun; that proportion being increased for such faces as are likely to be long under fire, or where the main magazine is unavoidably more remote from the expense magazines than in this plan.

3. "A plan embodying these general principles will be prepared, and the shell-filling rooms and room for filling cartridges will be shewn upon it.

4. "Colonel Jervois, R.E., placed before the meeting a proposed method of moving shells for casemates and for open batteries, which was generally approved; to be considered in detail.

5. "He also shewed a plan of transferring the cartridges from the magazine to the gun floor; on which it was observed that it will be preferable in all cases to bring up the shell at the nearest opening to the gun,† and the cartridge at the more remote one. The details will be further considered.

6. "Drawings in detail of artillery small stores, general stores, shell stores, side-arm stores, &c., will be prepared for consideration.

7. "The meeting consider that, when practicable, no work should be dependent on one magazine alone for its supply of powder.

"Particular attention should be given to the effective lighting of all magazines.

8. "A recognized nomenclature for every description of accommodation and arrangement should be adopted, and not departed from.

9. "The side-arms in casemates should be ranged along the interior of the arch.

"Having laid down the above general principles, the meeting adjourned for the present, to give time for the preparation of plans in accordance with them, and for further consideration of the general subject."

The Committee met again and considered the plans on 7th February, 1867. They were then carried out.

The accompanying questions, embodying the principal points which most nearly affect artillery defence, were drawn up in connection with the fore-

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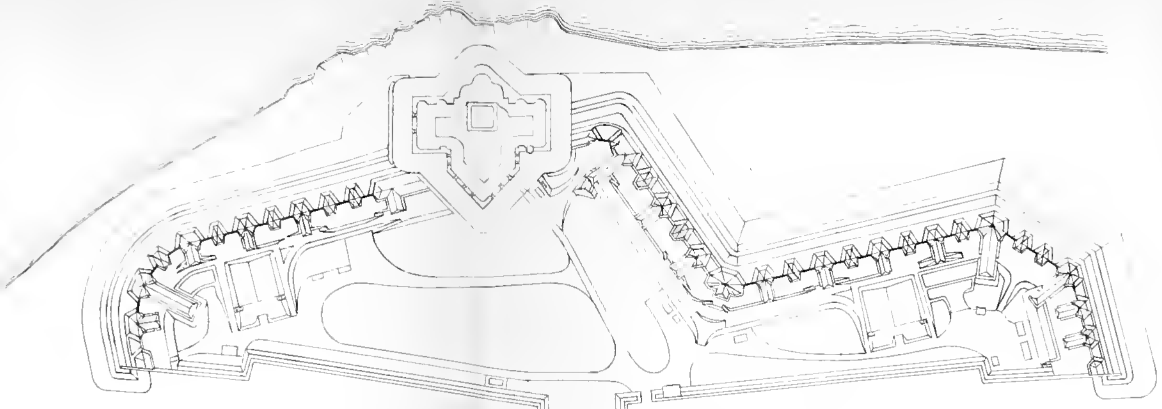
* On account of insufficiency of space, only a portion of the plan is given. A diagram has been introduced to explain the relative positions of the guns, the store rooms, and ammunition chambers.

† It was subsequently explained by Colonel Jervois, that the bringing up of the shell through a lift, placed immediately behind the merlon between two guns in a casemated battery, would be attended with disadvantage, as the traversing racks or tackle would lie across the mouth of the lift.

SKETCH SHEWING SOUTHSEA BATTERY.



Scale for Sketch 250 Feet to an Inch

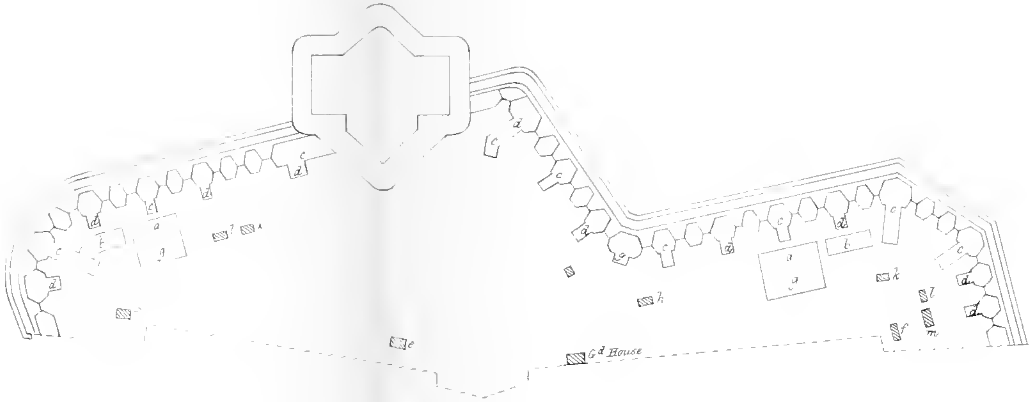
250 200 150 100 50 0 550 1000 Feet

Scale for Plans and Elevation 50 Feet to an Inch

50 45 40 35 30 25 20 15 10 5 0 50 100 150 Feet

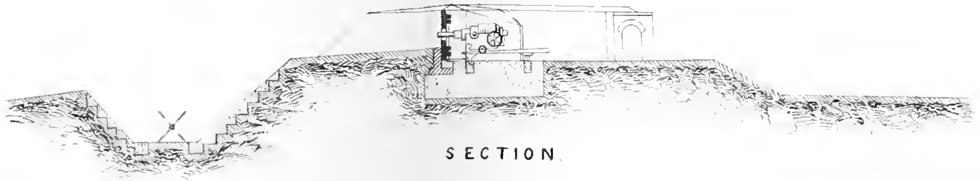
Scale for Section 25 Feet to an Inch

25 20 15 10 5 0 25 50 Feet

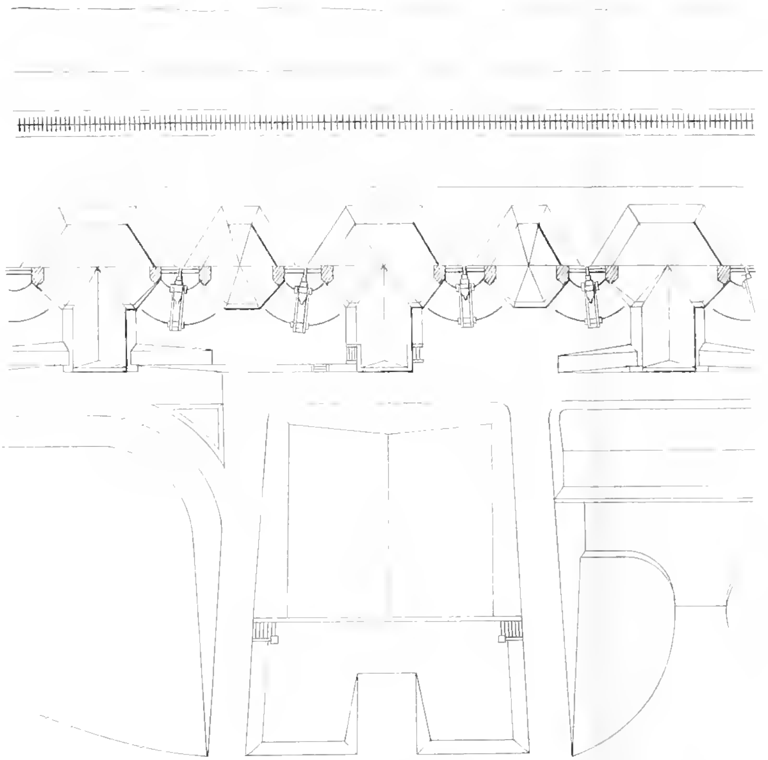


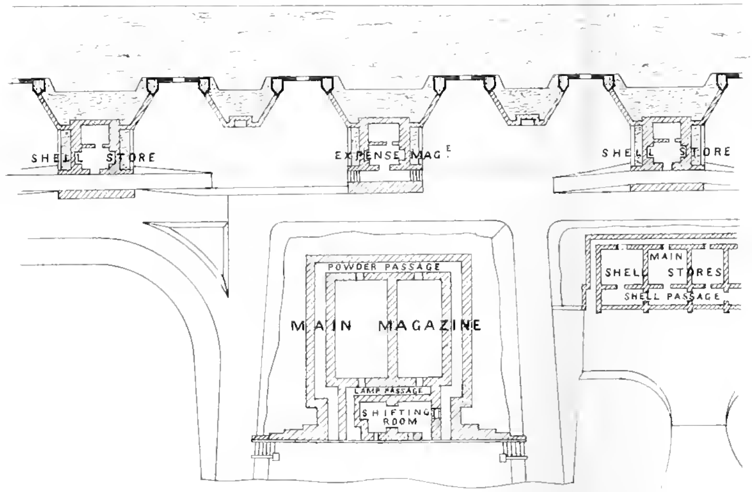
a	Main Magazines
b	Main Shell Stores
c	Expense Magazines
d	Expense Shell Stores
e	Laboratory.
f	Artillery General Stores
g	Artillery Small Stores
h	Side Arms and Tackle Stores
k	Side Arms Store
l	Tackle Store
m	Sling Cart and Gyn Shed

FRONT ELEVATION.



SECTION.





Wm F. Drummond Jervois

Lithographed at the Royal Artillery Institution

going discussion, and are here inserted as a help to the consideration of this subject by officers who may be called on to report upon it hereafter:—

(1) *Magazines.*—Is the communication between the guns and the expense magazines sufficiently direct and as well covered as circumstances permit?

(2) Are the expense magazines in the best situations in point of security, and convenient in point of access?

(3) Are the main magazines in the best situation in point of security, and convenient in point of access? Is the store of powder sufficiently divided to render all risks as small as is practicable?

(4) Are the doors or openings in the best direction, in reference to security under fire?

(5) Are the shell rooms and shell recesses sufficiently numerous, convenient of access, and convenient for the supply of loaded shells with rapidity?

(6) *Number of Artillery Store Rooms.*—Are they adequate in point of accommodation and size; sufficiently numerous; conveniently placed?

(7) *Traversing Platforms.*—Are the racers firmly laid and true in gauge? Do the guns traverse with the proper degree of facility?

(8) Are the *ground platforms* in good repair, the proper slope, and of sufficient size for the guns now mounted upon them?

(9) Are *traverses* sufficiently numerous, and do they give as much protection as the circumstances of the work admit of?

(10) *Splinter-proof Cover.*—Is there any protection provided against splinters of shells? Is there in your opinion room for its extension or improvement?

(11) *Cover generally.*—Are the parapets of the batteries high enough and solid enough to give a serviceable degree of protection?

(12) *Aids to accuracy.*—Are the heights of each battery, and the distances of conspicuous permanent objects within cannon shot of it, perfectly ascertained and permanently recorded at the battery?

The Committee above referred to having agreed on general principles, the subjoined memorandum was drawn up by the Deputy Director of Works, and embodies the instructions under which the officers of that Department acted in completing the works at Southsea Castle:—

Southsea 14/444

Ammunition.

1. "The amount of cartridges and loaded shells that it is proposed to provide accommodation for in batteries is 100 rounds* (100 per gun).

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* This number was fixed at a time when it was considered that shells would be used on all occasions. As now laid down in Circular on Ammunition and Stores—Garrison Service, the proportion of shells will be 65. The rest of the 100 are solid shot. Of these, some will be stored near to the gun, and the rest piled in a convenient place.

2. "The supply of cartridges provided for the guns, together with the proportion of powder in bulk (if any), and bursting charges for the shell, should be stored in the main magazines, and no portion should be stored (except under extraordinary circumstances), in the expense magazines, which are intended only for temporary use, when the battery is put in a state of preparation for action.

3. "The expense magazines situated in proximity to the main magazines, are intended to accommodate, under these circumstances, twenty-five cartridges for each of the guns to which they are allotted (usually for four guns).

4. "The expense magazines that cannot easily be replenished from the main magazines (as for instance those in the flanks at Southsea batteries), should receive not less than thirty cartridges per gun.

5. "The shells, when loaded, should be stored in the expense and main shell stores.

"If supplied unloaded, they should be stacked in the interior of the battery.

"Of the loaded shells supplied, a number equivalent to the cartridges destined for the expense magazines, should be stored in the expense shell stores.

6. "The remainder of the 100 shells per gun should, when supplied loaded, be stored in the main shell stores.

7. "The different natures of cartridges should be kept sufficiently distinct to prevent confusion. With this object, the bays in the magazines have been subdivided. The cartridges are packed in zinc cylinders, and can be piled to the extent of ten in height in the case of cartridges for 9-inch guns, and of guns of less calibre. Seven layers will, however, in general be found sufficient, and taking into account the extent of floor space allowed for the stacks, will be found to afford the necessary accommodation.

8. "The shells of 9-inch rifled guns, and of guns of greater calibre, should be made to stand on their bases in the shell stores. Smaller shells can be stacked.

"Owing to the great length of the service shells for 9-inch and 12-inch guns, no economy of space arises from stacking being resorted to, more particularly as the stacks of shells when thus arranged have to be kept well apart, and a free space provided for access to them. The labor of moving the shells from the store when in stacks, will also prove to be much greater, even with the assistance of machinery, than when the shells are made to stand on their bases.

"A traveller having been supplied for one of the main shell stores at Southsea, a comparative trial of the merits of the two plans can be instituted.

Artillery Stores.

9. "Of the artillery stores supplied for use in a battery, the side-arms, levers, tackle, and handspikes require least protection from the weather, and can be stored in light metal buildings.

"The approved method of storing them is to have them all under the same roof. One example of this kind of stores has been provided at Southsea. The other sheds provided for the side-arms and tackle were constructed before this method was adopted.

10. "It is intended that the side-arms and tackle for each gun should be kept quite distinct, so that they can be readily removed, and taken to the gun for whose service they are required.

"Each division of the side-arm rack is intended for the side-arms of two guns; the distinction between the two sets is maintained by the heads of those for one gun being at one end, and the heads of the second set being made to project at the other end.

11. "The 'artillery small-store buildings' are intended for the small stores *in use*.

"The principle of arrangement is that of separating the sets required for each gun. The plans of the artillery small stores furnished for the Southsea batteries, explain the proposed method of storing these articles.

12. "The 'artillery general store' is intended to take the *duplicate or spare stores*, tackle, and side-arms &c., that are provided for the guns, and that are under the charge of a master-gunner.

"No particular arrangement beyond that necessary to ensure economy of space, is in this case necessary.

"W. F. D. J."

October 12, 1868.

The batteries were not fully armed before May, 1869, when they had mounted :—

1 Shunt rifled 13·3-inch gun of 22 tons (the original BIG WILL. of 1863).
22 Woolwich rifled 9·0-inch guns of 12 tons.
9 Woolwich rifled 7·0-inch guns of 7 tons.

The general artillery store, the small-arm store, and the side-arm sheds were not finally completed, but were handed over temporarily. At this stage it was decided by the Secretary of State that the Commanding Officers of Artillery and Engineers, with an officer from the School of Gunnery, and one from the Department of Works, should report on the arrangements, which was done in July, 1869, and resulted in the subjoined report. Appreciating the great importance of diffusing throughout both branches of the service the best information on these subjects, the Secretary of State has sanctioned its publication.

J. H. L.

November 10, 1869.

Correspondence in respect to the examination and trial of the Side-arm Store, Artillery Small and General Store, Expense Shell Store, and Magazines, in the Batteries at Southsea Castle, armed with 13-*inch*, 9-*inch*, *and* 7-*inch M.L. Rifled Guns, by a Committee of Officers of Royal Artillery and Royal Engineers.*

Portsmouth 5
2870.

16/7/69.

COMMITTEE.

Captain and Bt.-Major W. J. Grimston, R.A.
Captain E. Harding Steward, R.E.
Captain J. E. Blackwell, R.A.
Lieut. J. du T. Bogle, R.E.

Side-arm Store.

"A store containing the side-arms, block-tackle bearers, buckets, wads, &c. for *twelve* guns was examined; also tried with the full number of men requisite to man that number of guns.

"The fitments and their arrangements appear well adapted for the purposes required. It is, however, suggested that in future this class of store should be constructed to contain the stores of eight guns only; for when the numbers of the twelve guns went for their stores, the crowding of the men at the doors was at first too great to permit of the speedy removal of the stores. It is also suggested that the doors should be made broader, that the tackle brackets be made 12 inches long, and of round instead of flat iron, and that pegs be added for the buckets. (Plate II. figs. 1, 2, 3).

Artillery "Small" Store.

"A store for the small stores (in use) for twelve guns was examined and tried. It is suggested that in future this class of store should be made to take the small stores for *eight* guns only, in order that it may correspond with side-arm store, if reduced as proposed.

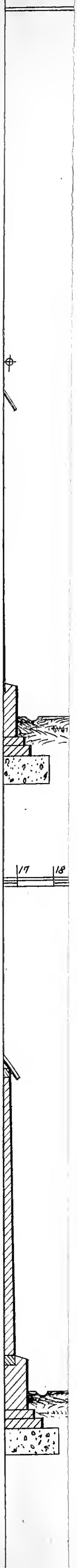
"It is also suggested that the divisions be marked on the bench by black lines, in order that the spaces devoted to the stores for each gun should be more apparent.

"It is also recommended that the 'preventor' rope should be classed with the small stores, and provided for accordingly; on account of the number of the gun detachment that procures it having also to get the sights. The store examined contains the small stores for five 7-inch guns and seven 9-inch guns. It is suggested that, where possible, the accommodation of the small stores of guns of different calibres in the same building, should be avoided. (Plate II. figs. 4, 5, 6).

General Artillery Store.

"A building for the reception of the spare or general stores for twenty-four guns was next examined.

"It is recommended that a few additional tackle brackets should be


17
18

STORE FOR SIDE ARMS & TACKLE.
[8 GUNS.]

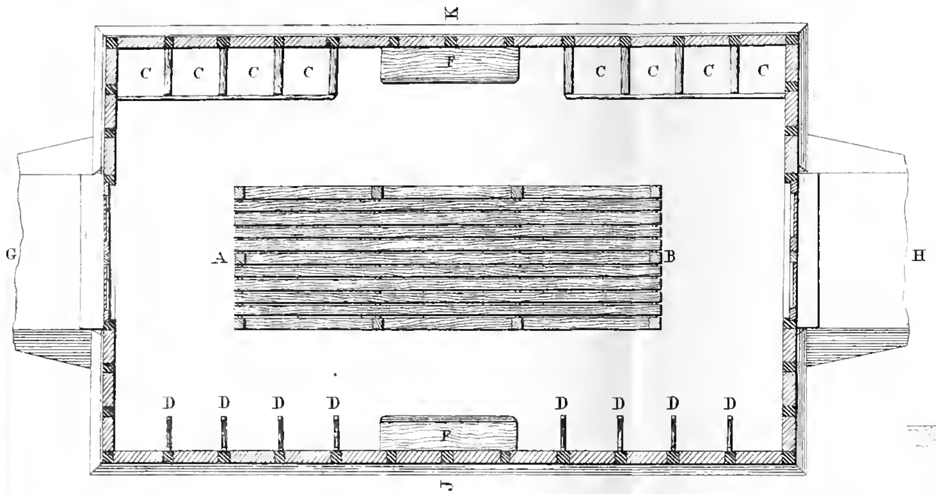
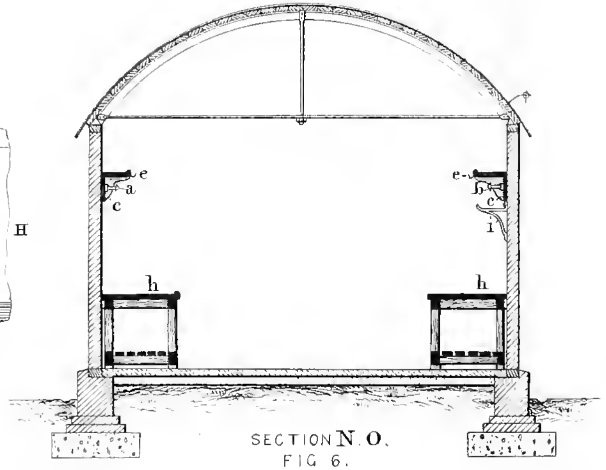


FIG I
PLAN



SECTION N.O.
FIG 6.

ARTILLERY SMALL STORE.
[8 GUNS.]

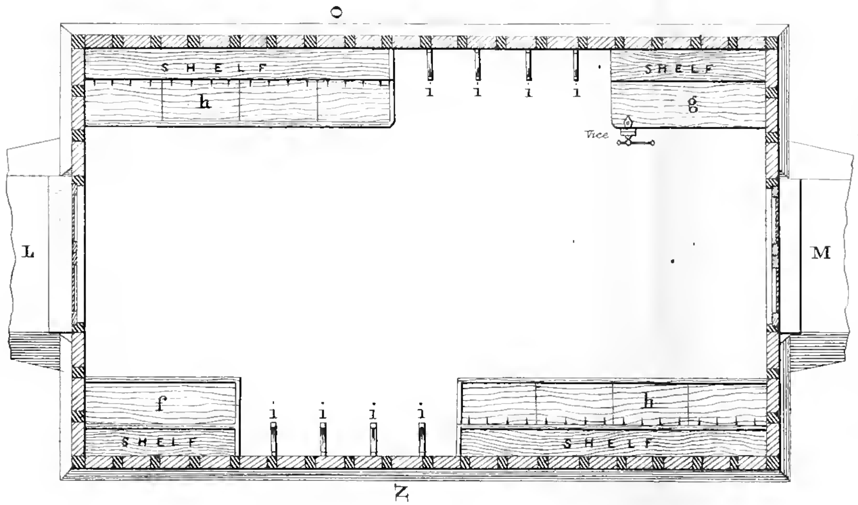


FIG 4.
PLAN.

REFERENCES FIG 1 2 3

A B.	Rack to take Side Arms
C C	Bays for Handspikes, Levers &c
D D	Tackle Brackets 2 for each Gun.
E E.	Hooks for Buckets 1 for each Gun
F. F	Shelves for brushes

FIG 4 5 6

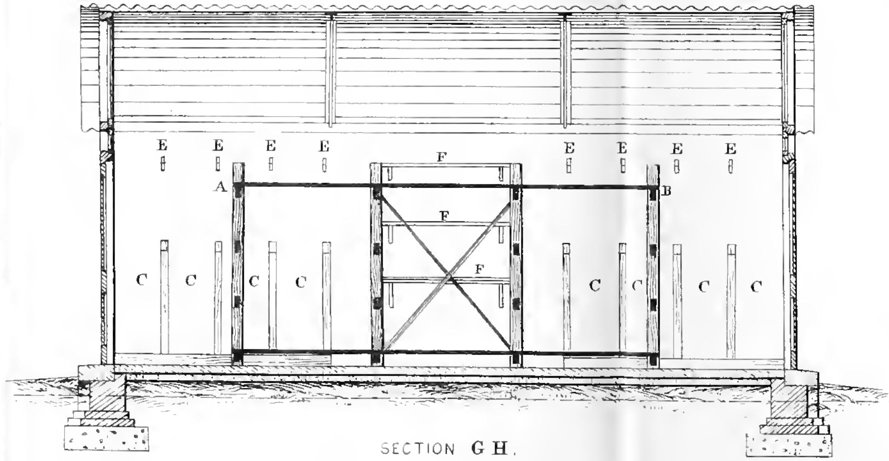
a b	Pegs to take Cartridge Cylinders 2 to each Gun
c. c.	Hooks to take Tube Box, hung by a strap
a a.	Label Plate to take card giving Nº & nature of Gun
e e.	Hooks for Prickers 2 to each Gun
f	Bench for Tools, Fitments, & implements
g	Cleaning bench with Shelf above
h h	Bench space for the small stores of 8 Guns
i i	Brackets for Preventer Ropes of 8 Guns

The heads of the Side Arms for 4 Guns be at the end marked A and those of the other 4 at the end marked B Fig II.

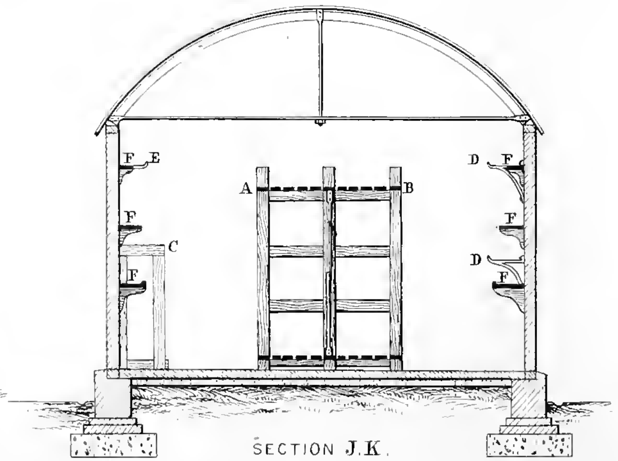
Note _ The Artʸ Small Store examined at Southsea, is made long to suit the site and therefore has the benches arranged on one side only. On account of this deviation from the general form of Store, another case has been substituted for it to match the arrangement proposed and recommended.

⊹ _ The Roof is lined with boarding to prevent the dropping of moisture that might be condensed on the Metal Roof.

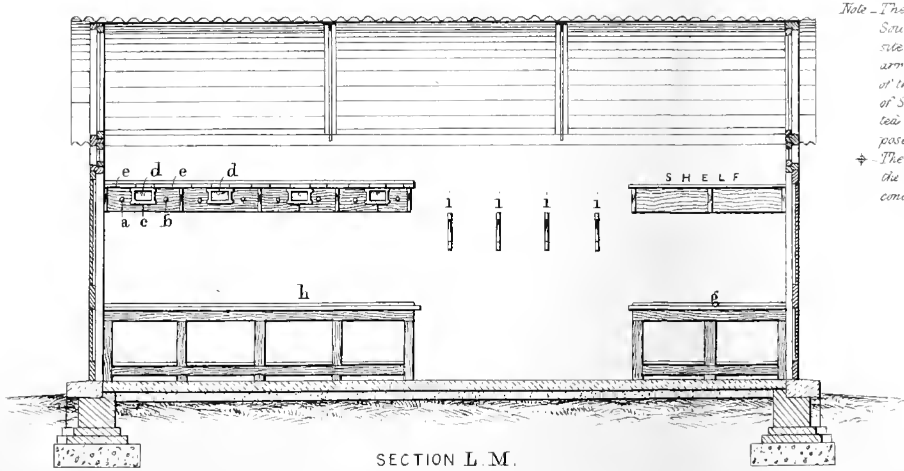
Scale 5 feet = One inch



SECTION G.H.
FIG 2



SECTION J.K.
FIG 3

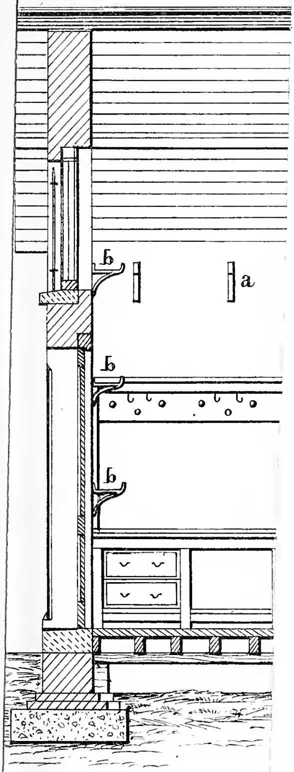


SECTION L.M.
FIG 5.

Sᵈ Wᵐ F Drummond Jervois

Lithographed at the Royal Artillery Institution

E.



Scale 5F^{t} = One inch.

13 14 15 16 17 18 19

h should be provided
ickle.
ts.

ARTILLERY "GENERAL" STORE.

[FOR 24 GUNS.]

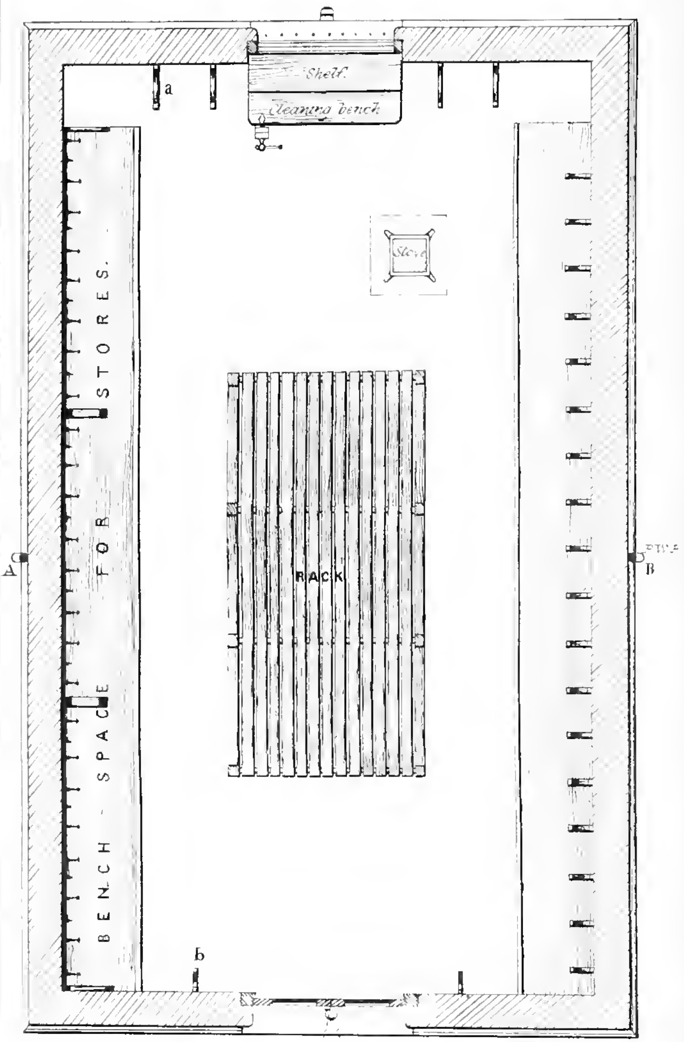
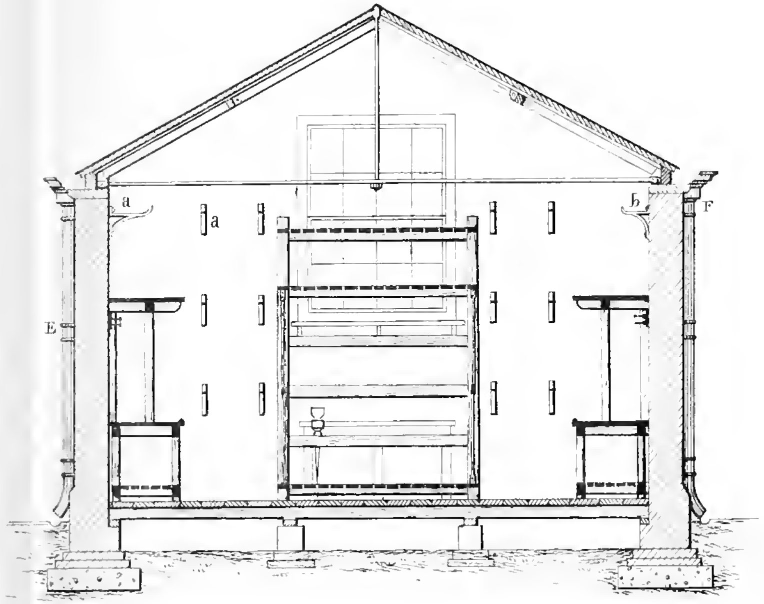


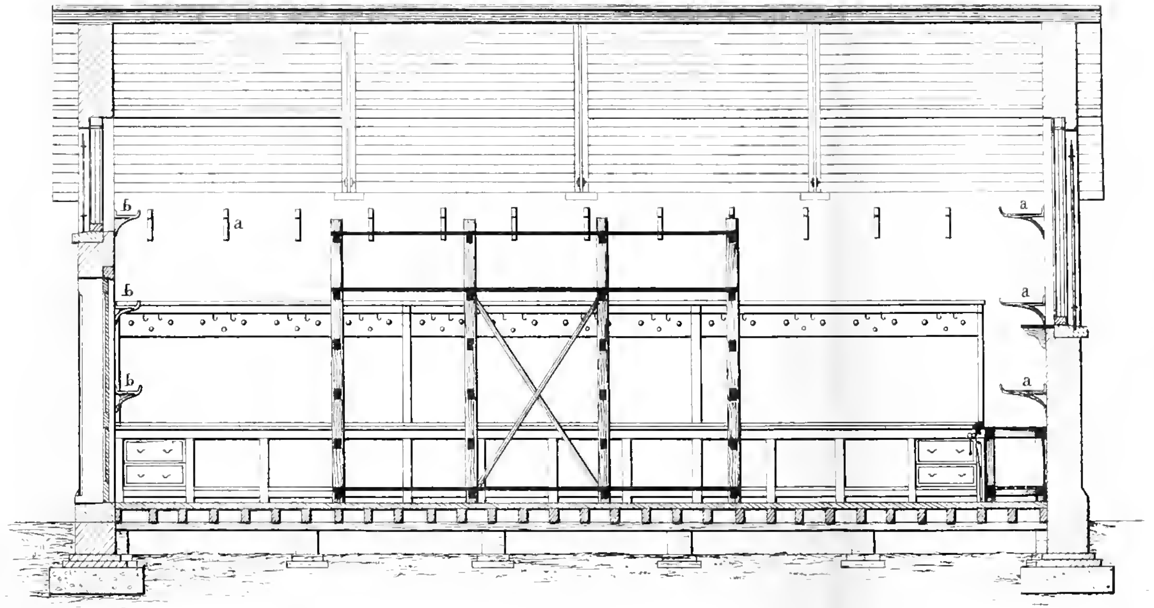
FIG I

PLAN

Taken on the left side at level **E** *and on the right at level* **F**
[FIG 2]

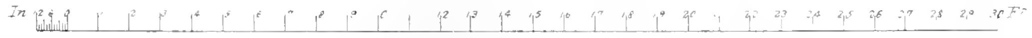


SECTION **A B**
FIG 2



SECTION **C D**
FIG 3

Scale 5 Ft = One inch



Note A light ladder 8^{ft} high should be provided
a a *Brackets for Tackle*
b b *Hooks for Buckets*

[illegible] Drummond Jervis

Lithographed at the Royal Artillery Institution

EXPENSE SHELL STORE.

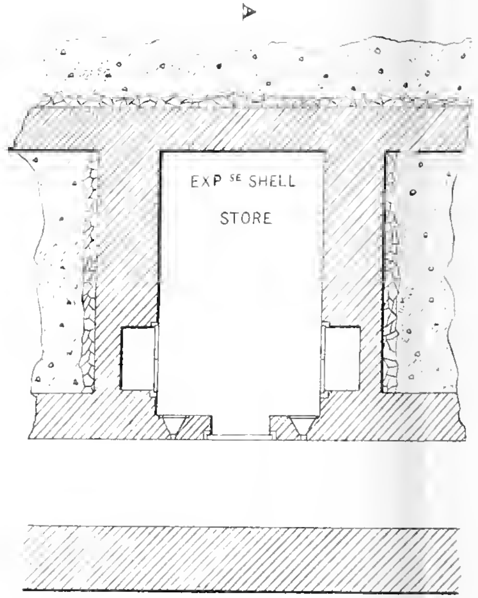


FIG 1

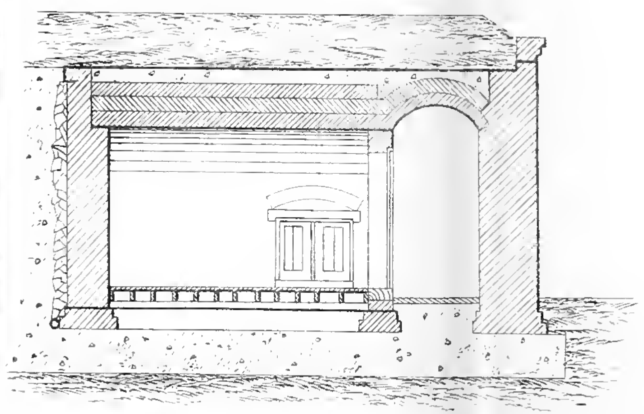


FIG 2

SECTION ON A.B. (FIG 1.)

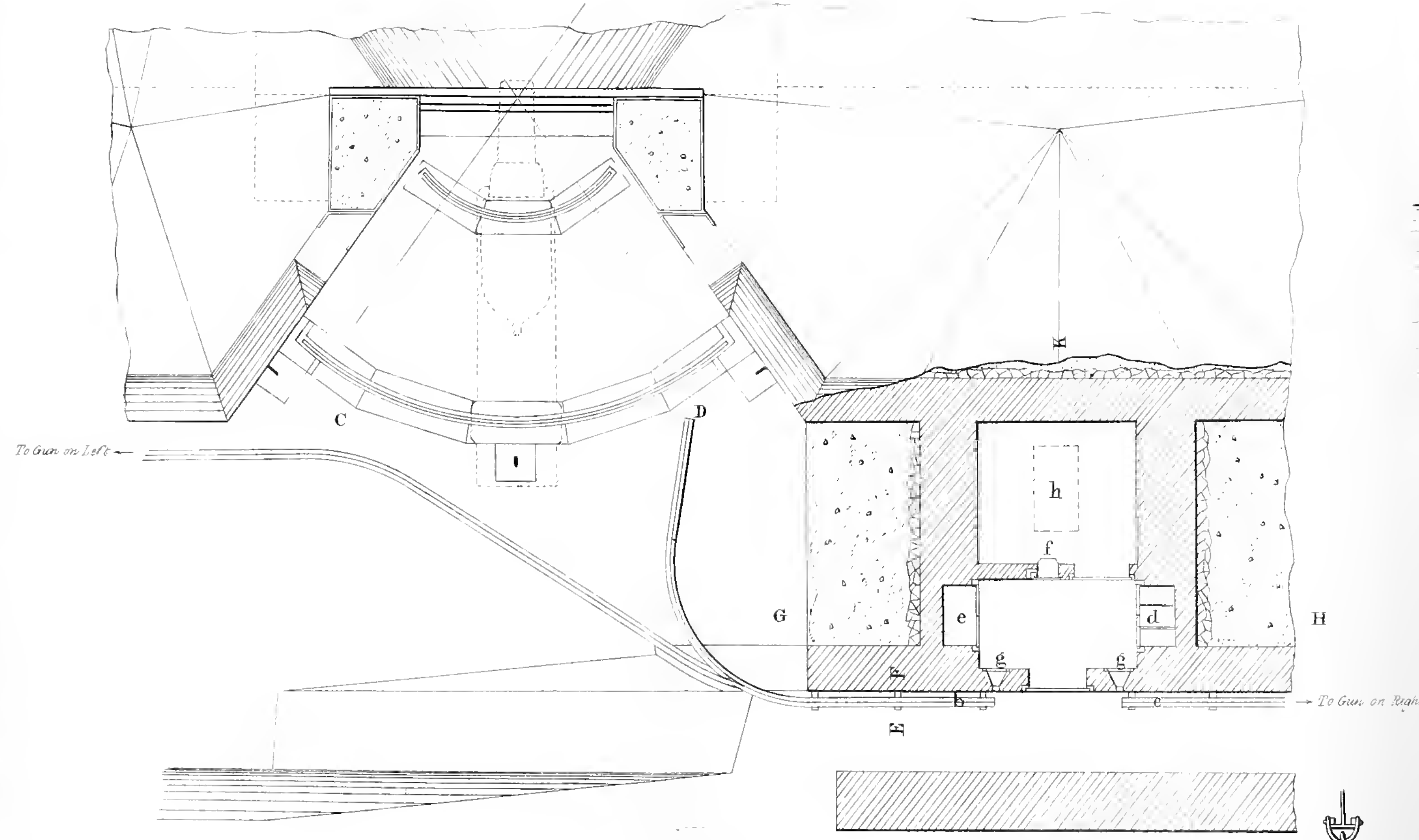
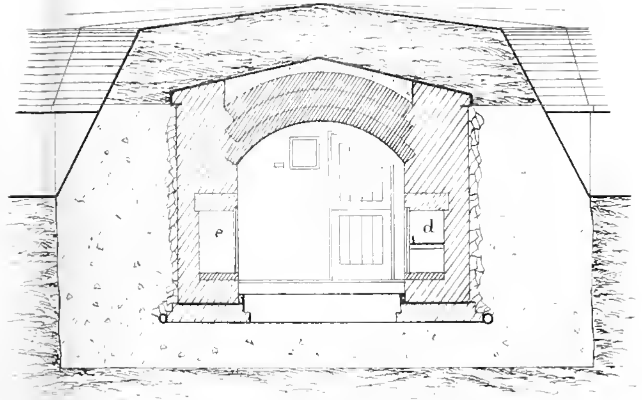


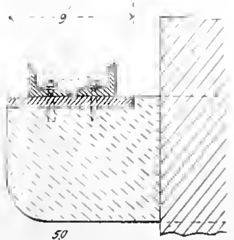
FIG 3

Note The Shot Rails are not shewn taken round the front of the platform as proposed, on account of the difficulty that will attend the laying of flush rails over the Racers, and because the chain of the Cunningham's training Gear will prove an obstacle to the passage of the Shell (when on the Rails) if laid, beyond **C** and **D**



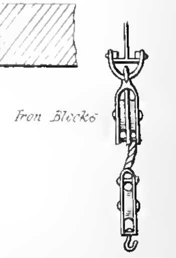
SECTION ON G H (FIG 3)

d Fuze Cupboard
e Recess
f Lamp Recess
g Recesses for hand barrows
h Hanging Shelf for grummet wads



ENLARGED SECTION AT E.F

A rope strap will be used in dragging the Shell along the Rails
Scale 1in = 1ft



Small overhead Traveller at **a**
The runner can travel from **b** to **c** (FIG 3)
Scale ½ in = 1ft

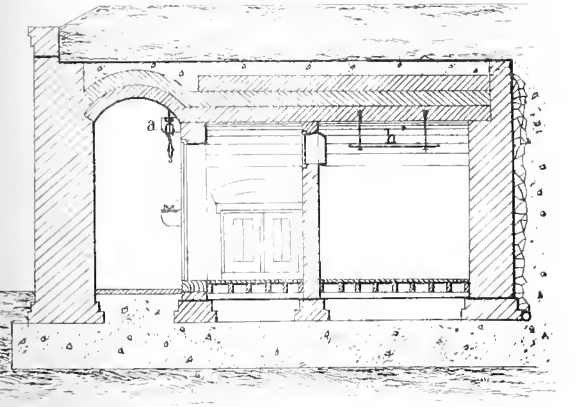
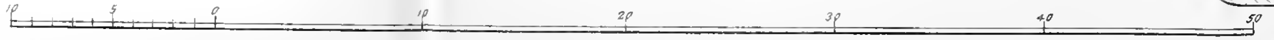


FIG 4

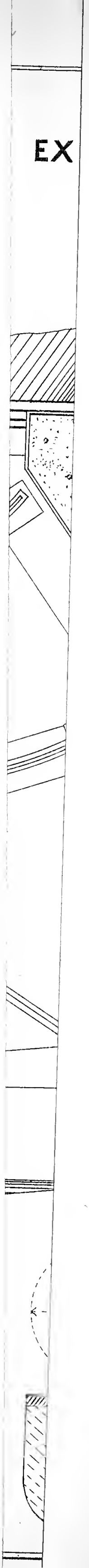
SECTION ON J. K (FIG 3)

SCALE FOR PLANS



Wm F. Drummond Jervois.

Lithographed at the Royal Artillery Institution.


EX

EXPENSE MAGAZINE.

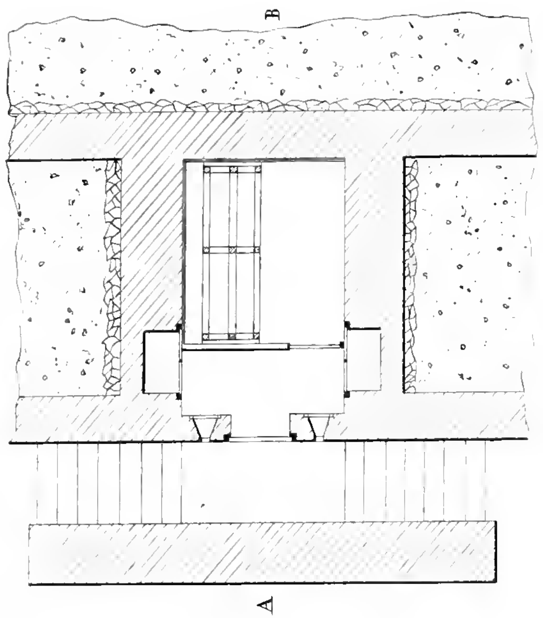


FIG 1.

Note-In order to show the proposed arrangement for Cartridges & Issuers it is necessary to lengthen the Chamber on Plan

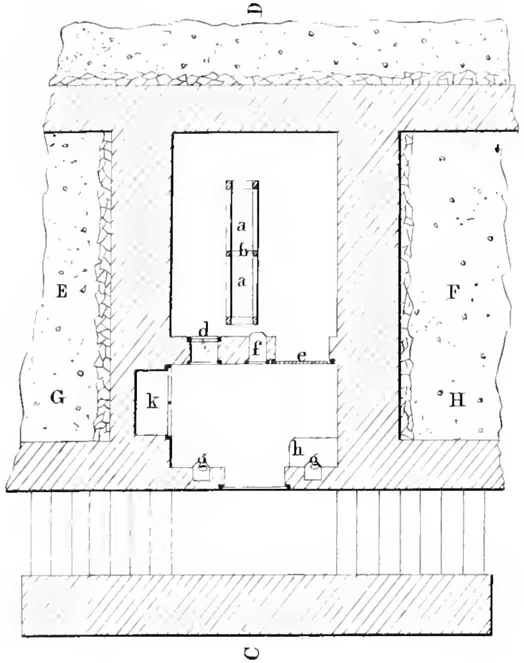
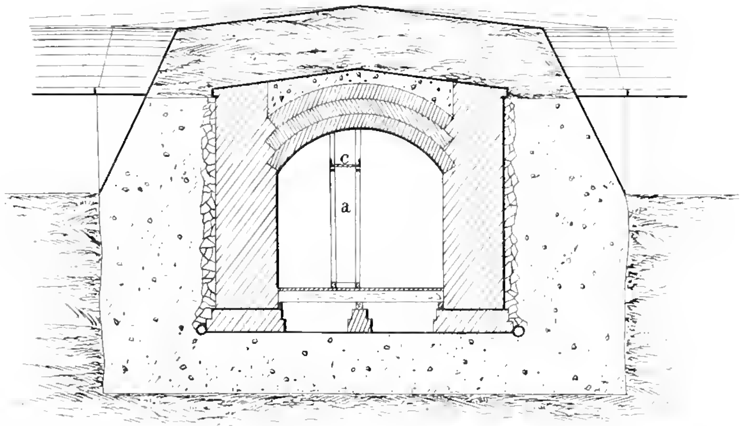


FIG 3.



SECTION ON **E F**(FIG 3.)

a	*Bays to take Cartridges in Zinc Cylinders*
b	*Studs to divide the Full charges from the Reduced charges*
c	*Rack above Cartridge bays to take Papier mache Wads &c*
d	*Powder Issuer*
e	*Door in halves the upper half to be used as an Issuer*
f	*Recess for Lamp*
g	*Recesses to take hand Lamps*
h	*Bench*
k	*Implement Cupboard*

The Expense Magazine shewn at Figs 3 & 4 is for the Service of two Guns

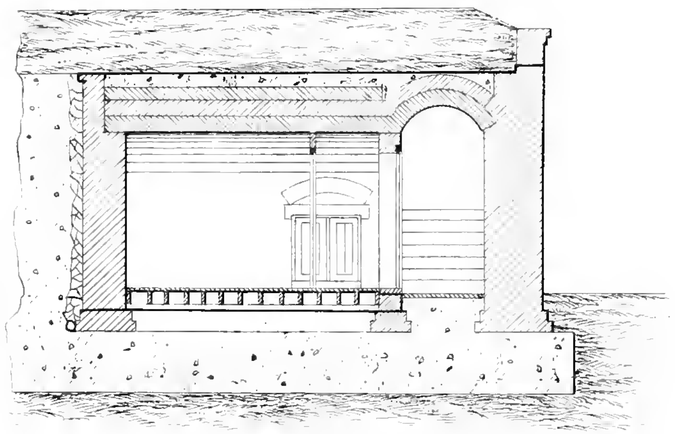


FIG 2.

SECTION ON **A B** (FIG 1)

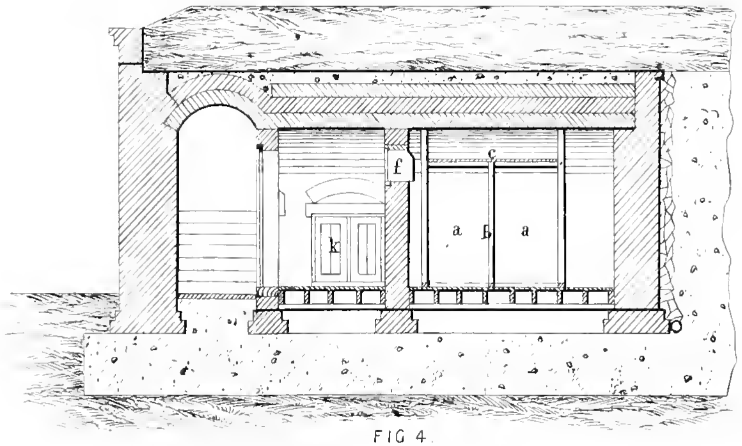
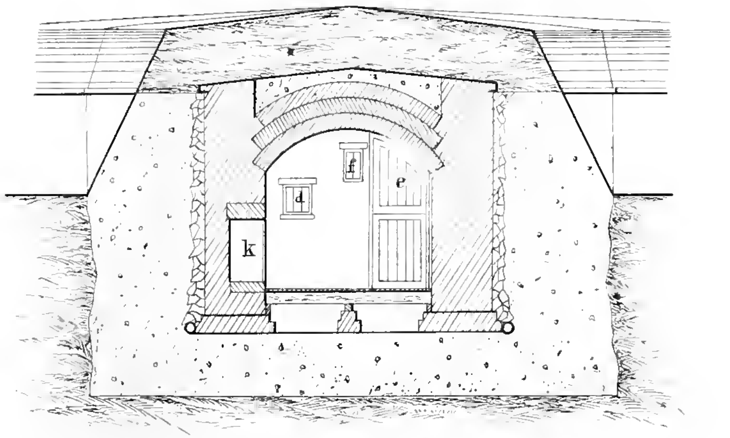


FIG 4.

SECTION ON **C D** (FIG 3.)

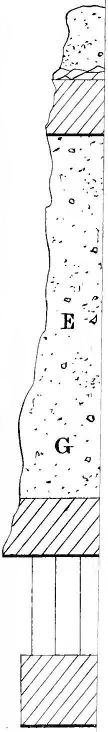
SCALE 8 FT = 1 INCH



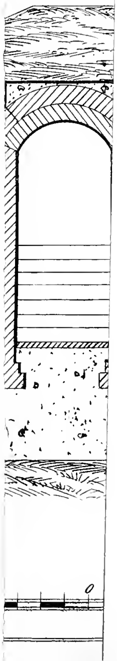
SECTION ON **G H**.(FIG 3)

Wm F Drummond Jervois

Lithographed at the Royal Artillery Institution



e Expense



introduced, and a short ladder provided, to enable the men to reach the top of the racks. (Plate III. figs. 1, 2, 3).

Expense Shell Store.

"An expense shell store for four guns was examined, and the service of shell from it tried. (Plate IV. figs. 1, 2).

"It was found to be capable of containing twenty-five shells for each of the four guns. It is however suggested that, in future, expense shell stores should not supply more than two guns, the reduction being proposed with the view of diminishing the confusion and delay that must necessarily arise when the numbers from four detachments come for shell at the same time.

"It is also suggested that a lobby should be provided in connection with an expense shell store, in which shells can be fuzed if necessary. With reference to the issue of shell from the lobby, it is recommended that a shell hatch at the level of the terreplein (provided on each side of the lobby), should be used for the delivery of the shell, shot-rails being employed for the transit of the shell from the mouth of the hatch to the gun.

"It is for consideration whether, at the expense shell stores at Southsea, the shell might not be raised by tackle at the door, and placed on shot-rails laid at the level of the terreplein, and be slided to the gun, in preference to employing trucks for their removal; as the latter cannot be worked without planking, on account of the looseness of the gravel. (Plate IV. figs. 3, 4).

"The expense shell store on the right flank of the west battery, which is provided with a ledge and rails in lieu of a ramp, and a small traveller with blocks and tackle for raising the shell to the ledge, was next examined.

"Suggested, that shot rails should be employed in other and similar cases in lieu of the ledge, as they will probably prove as efficient, and more economical.

"The patent unlocking differential pulley, also the tackle and small metal blocks for raising the shell, were tried. Some experience appears to be requisite to enable a man to use the differential pulley properly, and without which an accident might occur. The preference is therefore to be given to the blocks and tackle for employment with the small traveller.

"The metal clips for holding and raising the shell were tried, also a rope strap (selvagee), to effect the same object. The latter proved to be easier of application and quite as effective as the two clips, and is therefore preferred.

Expense Magazine.

"An expense magazine for the service of four guns was examined. (Plate V. figs. 1, 2).

"The chamber appears capable of containing conveniently the expense ammunition for four guns, and the bays afford the requisite separation of the two natures of ammunition.

"With the view of facilitating the service of ammunition to guns, it is recommended that the number of guns to be supplied by an expense magazine should be reduced from four to two.

"It is suggested also that the separation between the lobby and the magazine should be of brickwork. That the rack to take the cylinders should be placed in the middle of the chamber, with a passage (and door leading thereto), on each side; in order that the cartridges may be delivered to both guns simultaneously, and that the necessity for removing the zinc cylinders, when emptied, may be avoided. (Plate V. figs. 3, 4).

"It is also suggested that the doors of the chamber containing the cartridges should be made in half, the lower half being employed as a ledge for the cartridge when being issued.

Main Shell Store.

"The main shell stores were examined, also the traveller for stacking shells. It appears that the system of storing loaded shells on their bases is the preferable one, that the traveller worked well, and that there can be no objection to the system of stacking proposed, in situations where piling is necessary. It is suggested that for the transferring shell from a main store to the expense shell store, shot rails should be experimented with, and a further report made. It is considered that the rails will be found to offer greater facilities for the removal of heavy shell than trucks or carts, on gravel, and will probably prove more economical and as effective as a tramway, and much more easily laid and repaired.

"It is recommended that 400 feet (about) of shot rails, and a proportion of curved rails, should be supplied to the Royal Artillery at Southsea Castle, in order to test this matter.

Shell-filling Room.

"It is understood that a shell-filling room is to be constructed on the space near the entrance to the castle. As this site, though central for the battery, is far removed from the main shell store, it is suggested that a filling room should be provided contiguous to each range of main shell stores, and so situated that the empty shells can be stacked with convenience in its immediate vicinity.

Main Magazine.

"The main magazine of the west battery was examined. The fittings appear to be suitable. It is suggested that the shifting room should not be in the same block as the magazines.

"It is for consideration whether a cartridge-filling and shifting room should not be constructed on a site separated from the magazine, but conveniently near to it.

(Signed) "W. J. GRIMSTON, Capt. and Bt.-Major R.A.
"E. HARDING STEWARD, Captain R.E.
"J. E. BLACKWELL, Captain R.A.
"J. Du T. BOGLE, Lieut. R.E."

30/7/69. Colonel Wodehouse, C.B., Commanding Royal Artillery, and Colonel Hadden, Commanding Royal Engineer, in forwarding the above, concur in the same, with the following additions and exceptions:—

	Remarks made by Col. Jervois, C.B., Deputy Director of Works:—
"Recommended, that a side-arm shed for each of the 23-ton guns should be constructed under the parapet, close to the guns. "Emplacement for one gun only at present made."	*"This was intended to be done."*
Expense Shell Store.	*Ditto.*
"That a hatch for the issue of shells for the 13-inch guns be constructed in the wall of expense shell rooms, with lifts, shot rails, &c.	*"Cunningham's gear is applied to the gun in question, and the chain will prevent the shell being brought up on rails nearer than the end of the platform.*
"Shot rails to be flush with the ground and carried round the muzzle and back to the starting point, crossing the racers, a gap being left wide enough for traversing."	*"The supply of shot rails was suggested with a view of testing the practicability of this proposition in the case of guns worked by tackle."*
"In regard to par. 2, page 4, the Commanding Royal Engineer states that the gravel will, if rolled, consolidate and render the tackle unnecessary."	*"If chalk is added, and the gravel well rolled, the surface will be much improved, but not sufficiently so to dispense with shot rails or planking."*
"Adverting to the suggestion for shot rails, the Commanding Royal Engineer states that any alteration required can be effected by his Department, and that he does not concur in the issue of rails to the Royal Artillery as necessary."	

20/8/69. Major-General Lefroy, in transmitting the foregoing to the Deputy Director of Works, observed that the substantial suggestions of this report, in which he concurred, were:—

1. That twelve guns are too many to be supplied from one side-arm store: eight should be the limit.

2. That the same remark applies to artillery small store.

3. That, if possible, the stores of 7-inch and 9-inch guns should not be mixed in the same sheds.

4. That there should, if possible, be an expense shell store to every two guns instead of four.

5. And an expense magazine in the same proportion.

He added:—

"There are also a number of minor suggestions of a practical character, for improving the several stores and facilitating the service of the guns.

"I do not see why the Royal Artillery should not be supplied with 400 feet of shot rail as asked for, although the Commanding Royal Engineer seems to prefer to manage it for them. The officers serving the guns appear to me the most likely persons to discover by trial where shot rails can be used with the greatest convenience and economy of labour.

"The report of the Committee referred to on $\overline{4874}$, and this report, are documents of so much practical value, that I think they should be printed, or communicated to the Royal Engineers Corps Papers and Royal Artillery Institution 'Proceedings' for general information."

Deputy Director of Works to Director General of Ordnance.

2/9/69. 1. "I concur in the adoption in future of the suggestions contained in the report.

2. "Plans of the several store buildings and fitments, revised in accordance with the suggestions, are now being made.

3. "At the Southsea batteries, the slight deficiencies in the fitments of the stores and ammunition chambers will be made good.

4. "Other additions, such as the laboratory and shifting room, and the shell-filling rooms, were always intended to be made, when funds are voted for the purpose.

5. "As regards the shot rails, no doubt those which are *movable* should be supplied to the Royal Artillery, and laid and used by them where required. Some rails however (at the doors of the expense shell stores for instance), will be fixtures, and these will be provided and fixed by the Royal Engineer Department.

6. "It appears most important that there should be a full trial of the shot rails, and I am at present having a drawing made of rails, both straight and curved, adapted for the movement of *elongated* 9-inch shells.

7. "With regard to the last paragraph of your minute, the two papers you mention might be circulated with advantage, as you propose."

25/10/69. Deputy-Adjutant-General, R.A., to Director General of Ordnance, states that he concurs with him and the Deputy Director of Works, and would propose that the reports be printed for circulation.

27/10/69. Major-General Lefroy forwards to Lord Northbrook for approval, the proposal for transmitting copies to the Editors of the "Proceedings" of the Royal Artillery Institution, and Corps Papers Royal Engineers, as a ready way of giving publicity to this report; and this was approved by the Secretary of State.

ON THE

CONSTRUCTION OF BATTERIES.

BY

MAJOR GRIFFITH WILLIAMS, R.A.,

(*Circa* 1780).

[BEING A CONTRIBUTION TO REGIMENTAL HISTORY BY MAJOR-GENERAL LEFROY, R.A.]

THE discussion in the preceding paper on the batteries of the present day, will give additional interest to a paper hitherto unpublished, by an old soldier of the last century, on batteries as known to him; and there will be found in many of his remarks, that shrewd sense and military experience which is of no age, but belongs to all periods and all occasions. Griffith Williams, No. 131 of the recent edition of "Kane's List," some time Commandant of the Garrison of Woolwich, entered the Train of Artillery as a private in 1743, became cadet gunner in the following year, and obtained his commission in 1745. He served, as this paper testifies, at the siege of Munster, in Hanover, under Count de la Lippe, in 1759; at the siege of Belleisle, in 1761, and in the American War, 1777. The present paper is therefore, to some extent, a contribution to Regimental History, as I have ventured to call it: the old spelling has been preserved.

Major Griffith Williams was maternal grandfather to the late Major-General Lewis, R.E.

J. H. L.

MAJOR WILLIAMS'S METHOD OF CONSTRUCTING BATTERIES,

WITH REMARKS ON PART OF THE ARTILLERY SERVICE.

"The following remarks may be found usefull to such officers who have not had an opportunity of experience and practice:—

"Whenever the nature of the ground will admit of the water's being carried off by a small channel clear of your works, it is best to sink your platform by throwing the earth in front, in order to form your battery; but should it so happen that water cannot be carried off by a drain from your platform, you are to make a ditch of 12 feet wide in front of your intended battery, and throw the earth back. N.B.—All batteries should have a ditch of 12 feet wide before them, whenever the nature of the ground will admit of it, and when you sink your platform, the earth should be thrown between the ditch and the enemy. The ditch should not be less than 7 or 8 feet deep, which will be y^e means of preventing the enemy (should they make a sortie), from getting into your battery and spiking up your guns.

"Your magazine must be some distance to the right and left of your battery, and a line of communication to them, and not to have above 6 rounds to each gun in each of them at a time.

"Before you unmask your battery, and begin to fire at the enemy, you should clear your platform, as also every unnecessary article in the rear of it, to a good distance—in short, no one thing should be left but the guns, carriages and shot, as the enemy will, on discovering you, throw as many shells as possible they can into your battery, which will not only be destructive to every thing they fall on, but the pieces will wound and kill your men equal to shot; and for this reason the powder magazine must never be in the rear of your battery, as it would be in the range of the enemy's shells, and liable to be blown up every instant. Be sure that the limbers of your guns, and the triangle gin, are sent to a place of safety.

"When I had the honor of serving under his Highness Count le Lippe, at the siege of Munster (1759), he gave me orders not to carry any small arms on the battery; and at the same time, should the enemy make a sortie, I was in that case to retire with my men into a redoubt that was about 100 yards in the rear, and withall to the right of the battery that I commanded, and was manned with 100 infantry, for the purpose of driving the enemy out of the battery, should they enter, and attempt spiking the guns and destroying the works. His Highness did not allow any troops with small arms on the batteries; they were all posted in the lines to the right and left of all the gun and mortar batteries, and in the redoubts. I am thoroughly of opinion that no one artilleryman should, on real service, be incumbered with either carbine, musket, knapsack, or haversack. They are injurious to the artillery service; they destroy the power of the best and bravest men from acting in the manner they would otherwise do; they prevent the men from giving their assistance in bad roads to carriages, which they should do in going up hill, down hill, and in getting them out of sloughs and deep holes that are very frequent in bad roads.

"In all the service that I have seen, from the year 1743 to this day, it is inconceivable how ignorant all ranks and degrees of the army are, in regard to the proper method of preparing and providing for the attack and defence of places—particularly in the construction of works. As to the knowledge of the engineers, I shall not presume to give my opinion, except by saying that I could wish that their duty were entirely confined to forts and garrisons, and leave the duty of the field to the commanding officer of artillery, under whose direction all works for attack and defence should be carried on; and as such works would be for the safety of himself and the soldiery under him, they would be no doubt properly and well constructed.

"There is a battery constructed at Woolwich for practice (as I have been told), in order to show young officers and the gentlemen cadets the manner batteries should be made—*somebody should inform them it is the manner in which they should not be made.* I will undertake to affirm that such a battery would not be tenable against an enemy's works, if within 100 yards of the covert way; the enemy's small arms would not suffer you to load a gun, but would kill your men as soon as they offered to them, through the embrasures that are made of such breadth. In all garrisons and places of defence, the guns should be mounted on travelling carriages and truck carriages, used only in ships of war. The saving in materials for platforms would be great; and not only that, the carriage of such materials would be very considerable, and, indeed, in an enemy's country not to be had. It has happened so in Germany—viz. at Munster and Marburg, in 1759, under Count le Lippe; proper sleepers and planks could not be had at any rate. I therefore fell on the method you see in the model and plan. The great advantage in my method of raising, is the expedition with which they are completed and made ready for service—viz. a battery for ten guns will be finished in 24 hours, except the ground should be very hard, by a rock interfering, &c.

"Another thing is, that a battery of this construction is not easily destroyed or damaged by the enemy's fire, nor can any accident happen to it from your own firing. It is otherwise with batteries constructed for truck carriages; the merlons are beat down in one day's time, and you must be very active indeed if you are able to repair them in a night's time; and if your batteries are within reach of the enemy's musquetry, out of the covert way, or where they are entrenched, they will keep you in constant hot water, and kill and wound numbers of your men. I have been for hours when I could not prevail on the men to get on the works to open the embrasures; for the very instant they (the enemy), heard us at work, they fired vollies of small arms. I am speaking from my own knowledge: at Munster, a battery of eight guns on travelling carriages was constructed by me, within fifty yards of the foot of the glacis; and notwithstanding the very hot fire kept on it for some days, we had it not once to repair. At Bellisle, our batteries were raised by me, for guns mounted on truck carriages got from the shipping, and it is inconceivable the labour we had every night to repair the merlons; and what added to our trouble was the badness of the fascines, the want of witheys to bind them, and the want of knowledge in the officers and men to make them. When they were tied with rope yarns, they were continually taking fire. It may appear odd to people that have not been used to see fascines made, that there should be any difficulty in making them usefull: it requires a great deal of use and practice—the fascines made by my direction require eight men to carry them after they are bound.

"There is no one thing more necessary for an artillery officer to know, than that of making proper use of his ammunition and artillery stores. Sometimes it so happens that, when he falls under the command of an officer of the line, whose experience has not been the best, and whose orders he is obliged to comply with, he is often obliged to fire at unnecessary objects. I have known orders given for the firing of a 12-pr. at a man or two of the enemy at a thousand yards distance; a 13-inch shell at a mile and an half or two miles distance—which they called frightening the enemy (this always put me in mind of a man who threw £3 12s. pieces to break panes of glass in the windows of one he disliked).

"Officers, in general, think they never can have a sufficiency of ammunition, stores, intrenching tools, &c. &c., to march with the army; and their reasoning is—let us want for nothing; in answer to which I say, it is better to run the risque of wanting many things, than to be incumbered with a number and quantity of what it is a thousand to one you may never have occasion for.

They impede, and are injurious and destructive to the army; they have been the cause of many unfortunate delays, the consequence of which has proved fatal to this as well as other countries. Great experience is requisite in an officer, before he can be a judge of making a proper proportion for the artillery service; because, as often as the nature of the service differs, so must the proportion. To send heavy artillery with hussars and light infantry, would be as ridiculous as to send a party of artillery a snipe shooting with a heavy 24-pr.; and to order cannon to take post and fire on troops in cover or intrenched (and where a common musquet would do much better), would be the sacrificing your officers and men, and in the end perhaps the loss of your guns. It is not every officer can judge of the fittest position for guns, however; it is necessary for the information of officers who have not had experience, to be told that whenever they can command a range of 500 yards with their guns, to begin the attack against troops. Let the officer of artillery be assured that the troops can never advance so far upon him as to do him any material hurt; but let him remember, at the same time, never to take his guns to begin the attack with troops, within 100 yards of them—especially if they are in cover or intrenched—except he is absolutely ordered; and so sure as that happens, so sure the party and guns are sacrificed. Whenever light guns are sent on detachments, the ammunition and intrenching tools' carriages should be light for expedition—the more the weight is divided the better; I therefore by no means approve of any ammunition being laid on the limbers of the guns' carriages. As a proof of this assertion, I shall give a copy from my journal in America.

SCHUYLER'S ISLAND,
August 31st, 1777.

"Ordered 3 of my constructed carts to bring 24 cwt. of ammunition from Fort George, each carrying 8 cwt., 2 horses to each cart. They got here in 6 hours; distance about 19 miles.

"Ordered at the same time, 2 artillery wagons, each to have 9 horses, and to bring 24 cwt.—that is, 12 cwt. each. They were 2 days in performing what the cart did in 6 hours.

"Beware that you are not bit by your great professors of mathematics, and your great projectors, especially on service—from them, Good Lord deliver me! At the same time, it is highly and absolutely necessary to have a proper knowledge of the mathematics. Never make use of block with three sheves when one with two will do; nor one with two, when a single one will do much better—in short, never incumber yourself with mechanical powers to move what can be done by hand, nor put blocks and tackles to drag what can be carried by a few men on their shoulders. Theory must be usefull, but there must be practice to make perfect. I have seen men who could neither read nor write, make much better use of mechanical powers than all the masters of the Academy could do, were they to be put altogether. I should have but little dependance on them at a siege, nor indeed have I ever been under the necessity of calling any of the engineers to our assistance; neither have I ever been able to come at what the real duty of an engineer is in the field. I have heard some of them say that the laying platforms is not part of their duty.

"There is no part of the service where officers are more mistaken than in that of throwing shells so as to make them of that use and consequence which they were intended for. I have been at a siege where (in consequence of orders), I have expended near 13,000 shells; whereas, had I been left to my own will, I do not believe I should have expended 3000. Shells in my opinion were intended for two purposes only—viz. the heavy to pierce the ground, and by their explosion blow up batteries, platforms, &c., or magazines, casemates, granaries, wells, &c. &c.; therefore, in that case, the fuze should be calculated so as not to burn out until such time as you are sure that the shell falls. In order to be sure of this, you should make an allowance of four or five seconds. Small shells are (or at least should be), made use of for different purposes—viz. such as dislodging the enemy out of redoubts, intrenchments, or when they have taken post in such a place that you cannot dislodge them with cannon shot. The nearer you are to the enemy on this service the better, as small shells at a great distance are thrown with great uncertainty. The fuzes of small shells should be calculated so as to burn out before the shell falls; where a small shell falls and bursts, it leaves the most material part on the very spot where it falls, whereas had it burst some distance from the ground, that part would have had the chance of doing execution.

" Some of our artillery officers and engineers have taken great pains to find out a fuze that should cause a shell to burst the instant it touches the ground. The Master-General and Honourable Board gave their usual encouragement to them; but I honestly confess that, so far from thinking it usefull, I am thoroughly of opinion that it would be injurious to the artillery service. Whenever you get to the second or third parallel, the enemy get into the covert way, or intrench themselves, so as by their marksmen to fire on your men in the battery through your embrasures, and often kill and wound many; to prevent which, I have manetlets to put occasionally across them.

" Mortars throwing 10 and 13-inch shells, should not be fixed to any degree of elevation in their beds. At the siege of Bellisle, 1761, I was so near the garrison, that to a 13-inch sea service mortar, I made use of no more than three pounds of powder at an elevation of 45 degrees. Here it was evident that the shell of such nature did not answer the end proposed; I therefore fixt the mortar in the ground at 70 degrees, in order to give the shell that degree of velocity required falling.

" The quantity of scantling, plank, and spikes required to make a platform for one heavy battering piece of cannon on a truck carriage, as also the weight and value nearly calculated:—

	feet cube.
16 oak joists, 20 foot each, 9 inches by 6 inches	120
400 feet supr. of 2½ inches oak planks	84
Total	204

A foot cube of dry oak—weight 58 pounds.

	cwt.	qrs.	lbs.
Total weight	105	2	16
Allow for spikes (weight)	2	0	0

The whole will weigh about 5 ton.
Value of timber and spikes, £38.

"The quantity of scantling, plank, and spikes required for a platform of my construction, for one heavy piece of battering cannon on a travelling carriage; also the weight and value nearly calculated:—

Platform.

2½ inch oak plank, 9 feet by 7 feet.
4 oak joists, 7 feet long.

	cwt.	qrs.	lbs.
Weight of oak plank and joists	19	2	20
Spikes, about	1	0	0
Total	20	2	20

	£	s.	d.
Value of planks and joists	7	0	0
Spikes	2	2	0
Total	9	2	0

"The intervals between my guns on this battery of my construction, serve for a mortar battery, and are to be used as frequent as the guns or as the nature of the service may require—which I look upon to be a very great advantage.

"I have not as yet been able to bring myself to approve of the works of many of the engineers that I have met with in our service; perhaps it was my misfortune in having different ideas from theirs.

"Various have been the inventions of some of the officers of artillery and engineers in our service, as well as a very great variety of other people of almost all professions, for improving of our guns, carriages, and all other implements of war in our Royal Artillery service; and our Master-Generals and the Honourable Board of Ordnance have given every encouragement to men of invention, and some they have rewarded; but how far they mean to adopt any of the new inventions for real service, I cannot pretend to say—I should hope not many.

"I have, on many occasions, endeavoured to prevail that no piece of ordnance of a less caliber than a 6-pr. should be sent on any service whatever. A light 6-pr. can go wherever troops of every denomination whatever can be sent; and, with equall speed, my constructed carts with two horses carried 124 rounds for a 6-pr., as also every other necessary belonging to the men, as well as what was requisite for the service of the guns.

For two light 6-prs.	4 horses.
For two carts for ditto	4 ,,
To carry 124 rounds for each.	

To carry ammunition for two medium 12-prs.	4 carts.
Horses to ditto	8
To draw the guns	10 horses.
If the roads are very bad	12 ,,

"Guns of the above nature are the only ones I should apply for to the light brigades, and the above proportion of ammunition is very sufficient for any detached service. I would not be understood to mean that there should not be more in the artillery park, with the heavy guns—which guns I should chuse to be 24, 18, and 12-prs. As I have found the greatest inconveniency in stowing the carriages of different kinds in small boats, so as to enable the men to row, carts of my construction differ much from those used in ours or any other service; and as the limbers of travelling carriages are the most difficult of any part of the train for stowage, I have made the shafts to ship and unship in the axletree, by which means they lie flat.

"Notwithstanding we calculate the force it requires to draw the different nature of guns and carriages, &c. &c., that makes up the train belonging to the artillery, yet all depends on the goodness of the roads, and the goodness of the cattle. For example, in November, 1759, when I was sent to Hanover to bring some heavy 12-prs. (brass), to carry on the siege of Munster, I made a demand for twelve horses to each gun, which did tolerable well for the first and second days; but before we got the guns to the batteries, we were at times obliged to put 36 horses to one gun. When we landed our sea mortars at Bellisle, we had 40 horses to attempt drawing one of the 13-inch mortars, but to no purpose; 200 men drew it with ease. From the carrying place at Ticonderago to Lake George, which is not more than one mile, we had 24 oxen to draw one of our gun boats.

"The hurter that all engineers fix between the gun and the front of the battery, should never be admitted, as it prevents the gun from piercing the embrasure almost a foot less than what it otherwise would do; and no one thing can be so clear as to know that when your gun does but just enter the narrow part of the embrasure, it must blow your merlons to pieces, if not set them on fire. There is another thing the engineers do, equally as absurd—viz. the great slope they give the platforms (inwards); and for this reason, when your gun is fired, and recoils to the extreme part of your platform, it becomes exposed to the fire of the enemy, as being almost on a level with the sill of your embrasure; so that your gun carriage is entirely open, and must be dismounted before your men can run it up—as you must suppose your enemies will avail themselves of so favorable an advantage.

"All artillery officers who have had experience, must know the great advantage guns from batteries have over shipping; however, as we have not many that have had an opportunity of seeing all kind of artillery service, by sea and land, I shall not only set down my opinion, but likewise set down the memorandums I have made on service. There is no man can be a good military engineer, but at the same time must be a good and able general; as the requisites for both are required in one. All the great powers in Europe have established Corps of Engineers, whose business seems to be mostly employed in building and constructing houses, wharfs, piers, &c. &c.; such engineers with more propriety should be called Controllers of Works. The late Lord Toraly was the first in Europe who saw the absurdity of batteries being carried as near as possible to the water's edge, as thought the best situation against shipping. That noble lord and great general took a different position for his batteries at Gibraltar, by retiring back between 400 and 500 yards, and carrying lines of communication from the garrison through the red sands to the southward, at the same time making some flanking batteries. In consequence of his lordship's having executed this plan, he would bid defiance to all the shipping in the world that should come to attack that garrison; whereas, before his lordship's time, it was not tenable against ships of war. Places of strength are often given up because the officers commanding in them do not know their real strength, and the advantage they have over the enemy; Gibraltar is a place that can never be taken by shipping, nor ought it to be taken by land. Engineers and governors of places often weaken their garrisons by additional works, and I am of opinion that the bastion which has cost so much money at Gibraltar, has by no means added strength to that garrison. The French engineers at Munster, in Germany, and at Palle on the Island of Bellisle, constructed several redoubts in front of the works at both these places; they all fell to us as soon as we were ready to attack them—those very works must have been made by us, if they had not been made by the French.

"When we attacked Bellisle, the first thing we did, was to send three ships of the line and two bomb ships to attack a four gun battery that was close to the water's edge. The battery was silenced, but we could not make our landing good; our ships got within pistol shot of the battery, our loss was very great, both in men and boats, and had that four gun battery been retired 400 yards back, it would have beat all Commodore Keppell's fleet. In about 14 or 16 days afterwards, we were to have attempted landing in another place; but first of all, there was a battery of two guns to be destroyed by our shipping. The little battery stood upon a hill, and distant from our ships about 500 yards at most; the ships sent in by the commodore were one of 90 guns, two of 74, and two bomb ships that I had the direction of. The three ships of the line fired many hundred shot at the two guns without ever touching them, and had it not been that our false attack made the landing good, we must have been beat off by the two 12-prs. I would therefore recommend to every artillery officer who has it in his power to raise batteries of defence against shipping, to observe the distance I have mentioned, and be assured that with a very few guns, on a battery of my construction, no number of ships could stand against it; for every shot fired from the battery would do very essential damage to the shipping, and all the shot the shipping could ever fire, would do the battery but little, if any damage.

"Officers very frequently debate and argue about guns and mortars, in regard to the distance they carry—some for one sort and some for others; half the guns and mortars that have been rendered unserviceable, from the beginning of time to this day, have been spoiled by firing them at too great ranges, and giving them too great a charge of powder. I must own that I cannot see (except on some particular occasions), the use of firing any piece of ordnance to any greater distance than what you can, with some degree of certainty, direct it with your eye. I would not have any officer fire his guns because the enemy's random shot reach him; except, as I said before, on some particular occasions—viz. such as the enemies' line forming, or their advancing or retreating in columns, &c. &c.

"During the whole course of my service, I have looked up to with pleasure and honored the three great men who, I may say, first established and made our artillery, during both the last wars, so respectable. Before their time it was a mere nothing; and though in different departments, their zeal and great knowledge of the service was such that made them valuable to this country. One was the late General Belford, the present General Williamson, and the other the present Surveyor-General of the Ordnance, Sir Charles Frederick.

I do not remember any one thing relative to the service that they recommended or projected, but what was usefull and serviceable. I looked up to the former as the first artillery officer in the world, and the latter great indeed in the department he held in the Ordnance.

"The very great inconveniency I have always found in our having on foreign service the very heavy thill and trace harness, has induced me to make others much more suitable for our light artillery. The weight of them is one objection; there are many others—viz. they seldom fit the horses of other countries, as the horses of every nation differ from one another in make and shape. In consequence of that different make of their shoulders, they soon become sore, and of course when you put them to the carriage in order to march, they will not touch collar. Another very great inconveniency is, that when you are ordered on a service to keep your artillery horses harnessed by the Commander-in-Chief (which I have known to be done by Prince Ferdinand and the Hereditary Prince of Brunswick for many days together), the horses cannot feed: for this reason—if you slaken the collar, it falls on the horse's head; if you keep it buckled up in its proper place, the horse cannot get his head to the ground so as to feed; and no one can, but such as have had experience, judge the distress we have been in—particularly so when we were obliged to take them to grass or corn fields, some place near the guns and carriages. The same plague attended us through Canada, and after passing the lake.

"The harness that the Hanoverians, Germans, and the Americans use for draught, are infinitely superior to ours; and I must say that a kind of horse harness made use of by the people at Philadelphia and at Albany, are very usefull and handy. The harness of my construction are not like unto either of the before-mentioned; indeed mine are of two sorts—the one for great draughts, and the other for smaller; and through all the artillery service, I consider it to consist of two parts—viz. the heavy and the light—and the method that I adopt for the one, differs of course from the other.

"There is no one thing more necessary for to be considered by Government, than to find out the way of making carriages and packing boxes, &c., that take up the least room in stowage. It is not of so much consequence at home; but when you consider the many thousand tons of shipping is saved by what you are obliged to send abroad, it becomes an object of great consequence. One ammunition waggon takes up more room than six of my constructed carts, that carries the same weight.

"The ammunition boxes that are now in use with us, make very great breakage; the one for fixed case shot, that carries 12 rounds, is—

	ft.	in.
Length	2	7
Breadth	1	1½
High	0	10

The one of my construction, that carries 14 rounds, is in

	ft.	in.
Length	2	4½
Breadth	0	8½
Heighth	3	8

"In embarking or disembarking of artillery and carriages in the night, and of course with as much expedition as possible, things cannot be too complete, so as to be easily put together; and particularly so when you are so situated as to have only small battoes and small boats to carry them.

"The present method of packing ammunition never has, nor never can answer, if your artillery is to have a great deal of marching. I have experienced it often in Germany, in America, and every part of the world where I have been; and I have again experienced it by overhauling and examining all the fixed ammunition at Winchester, when I found the greatest part of what had been out with the battalion guns unfit for service, and many of the boxes that had only gone from Woolwich to Winchester, had many cartridges rendered unfit for service.

"My method of packing ammunition differs from any that I have yet seen, and I believe will answer better.

"There has been so much wrote and said on fortification, and the attack and defence of regular places, that I shall not speak anything of them, although I might with some degree of knowledge—having studied them in my younger days with great labour, under that able gentleman, Mr. Jno. Muller, late Chief Master of the Royal Academy at Woolwich. But I do intend to add to this medley of mine, my remarks and opinion on all the temporary works that I have seen in the different parts of the world, beginning with Chatham lines, and the works of them; Sheerness, Dover, Portsmouth, Plymouth, and its environs; the different works, and the variety of lines in Canada; the rebel lines at Stillwater, and all that I had an opportunity of seeing through all their countries where I passed; the lines on Long Island, New York Island, King Bridge, &c.; and the various lines and works at and near Philadelphia. My remarks on long and extensive lines, shall be such as to expose the folly of them."

HEAVY RIFLED GUNS.

BY

CAPTAIN HAIG, R.A., F.R.S.

The prospect of another Armstrong-Whitworth gun competition affords a good opportunity for explaining the circumstances which have led to such a juncture, for defining a few of the broad issues of such a contest, and for examining the position in which the country now stands in the matter.

The time has surely arrived when it is desirable at least to put an end to the personal nature of the contest as between Sir William Armstrong and Sir Joseph Whitworth. Various tribunals, differently constituted, have sat in judgment upon the performances of these favoured champions, and have recorded their opinions upon the various issues. So long has this duel continued, that every fresh opening of the question has now the character of an attack upon the competency of the legitimate advisers of the Government, who are thus put again and again upon their trial. The Ordnance Select Committee (in their Report, No. 4443, 9th January, 1867), appears to have been driven by a kind of despair, at the everlasting recurrence of the subject, into a recapitulation of the number of times that it had already been discussed. They say, § 11 :—

> "It appears from a table given at pp. 295–7 of the Second Report of the Parliamentary Committee on Ordnance, that no less than twelve committees, acting under the authority of five Ministers of War, have had Mr. Whitworth's system of rifling for small-arms or guns, or both, under special consideration since 1855. No one of these committees has been able to make such a report as to warrant the Government of the day in introducing his system. For several years past it has obtained great notoriety, and been backed by great ability, energy, and influence, notwithstanding which not a single foreign Government, so far as the Committee can learn, can be said to have adopted it further than by the purchase, like our own Government, of a few experimental guns; and yet the system has been fully tried, not alone by those whom Mr. Whitworth appears to regard as prejudiced or incompetent judges in this country, but by experienced and able officers in almost every other."

The waste of money incurred by these repeated trials is bad enough, but is by no means the most serious evil which they produce. Our experimental staff and means, though large, are not unlimited; and if they are occupied by this one interminable question, others which would lead to a real advance in our knowledge must be postponed or altogether excluded; and so it may easily happen that, although our expenditure in artillery experiments far exceeds that of any other country, our actual progress may be less, and we may find ourselves distanced in the race for supremacy, not from any want of energy or means, but simply from the misdirection of our efforts.

There is but one Royal Gun Factory, one long range where the accurate shooting of a gun can be tested, and but one convenient place for the conduct of iron-plate experiments, and these are all under the immediate control of the Secretary of State for War.

The Admiralty are therefore dependent upon the War Department for their guns, and although they can make a demand for a special pattern to suit either a new class of ship or to accord with a newly adopted set of artillery theories, such demand is liable to meet with objections; as, for instance, that there is already a land service gun almost the same size as the one demanded, that it is most undesirable to multiply patterns, and so on.

There is, in fact, a duality of administration as regards naval guns which cannot but tend to jealousy between the two Departments.

It also opens two doors for the admittance of gun inventors who, if they fail to effect an entrance at one, do not fail to redouble their importunity at the other. It is known that in France, Prussia, and Italy inconvenience has arisen from a similar want of good understanding between the naval and military authorities.

It must not, however, be supposed that any difference of opinion exists between the professional advisers of the War Office and Admiralty, or between the officers of the navy and artillery, on the question of heavy guns; on the contrary, both services alike are satisfied with their heavy wrought-iron guns, from the gun of 6½ tons weight to that of 25 tons. They further concur in condemning the Whitworth system in the most unequivocal manner and upon substantial grounds, which have been repeatedly brought to the notice both of the Lords of the Admiralty and the Secretary of State for War. Abundant evidence of their opinions may be gathered from the Parliamentary papers, entitled "Correspondence respecting the Trials of the Whitworth Guns, &c. &c." ordered to be printed 6th June, 1867.

At pages 28–9 of this correspondence will be found a report by the Captain of the *Excellent;* at pages 24–6 and 32–3, reports of the Director-General of Naval Ordnance; at pages 6–7 and 10-16, reports of the Ordnance Select Committee; and at page 27 a report of the Director of Ordnance. All these reports point to the same conclusion, viz. that it is undesirable to make any further trial of the Whitworth system.

In referring to our experience of the service guns, it will be impossible to enter into details. Such a record would fill volumes.

These guns are still made substantially on the principles at first advocated by Sir W. Armstrong. Some alterations have been made, both in the method of rifling and in the number of pieces of which the gun is composed, but only such as have been suggested by the extended trials to which the guns have been subjected, and by increased experience in their manufacture. Great credit is due to those who have been instrumental in introducing these alterations, but the guns are still coiled wrought-iron guns, with steel tubes and with rifle grooves, adapted to receive soft metal studs attached to the projectile, as originally proposed by Sir W. Armstrong.

Our experience, then, of the Armstrong gun dates from July, 1855, when the first of six guns ordered by the Government was delivered. (See "Ordnance Blue-Book" of 1863, p. iii.)

At that time, and for several years later, it may be said that Sir W. Armstrong had no competitor as a manufacturer of rifled guns. It was not till 1859 that Sir J. Whitworth manufactured a gun, so far as the Government has any experience, nor till 1863 that he made even a 70-pr. strong enough for the requirements of the service.*

In 1863 a committee of the House of Commons reported:—"Your committee have no practical evidence before them that even at this moment any other method of constructing rifled ordnance exists which can be compared to that of Mr. Armstrong." (Report, p. iv.)

Thus it came to pass that in 1863, before a single heavy Whitworth gun had been produced, the Government possessed as many as 800 Armstrong breech-loading 100-prs. of about 4 tons weight, and more than 1400 of the smaller natures, down to 12-prs.

They also possessed at least eleven muzzle-loading rifled guns built on the same plan, and weighing from 4 tons up to 22 tons, besides others not rifled.

Many thousands of rounds had been fired from the breech-loaders, with results which gave every confidence in their strength.

In the 100-prs., however, the original charge of 14 lb. of powder and 110 lb. shot was reduced to 12 lb. and 100 lb. on account of the insufficiency of the vent-pieces to stand the heavier charge.† The trials of the muzzle-loaders were equally satisfactory as far as they went, and showed that the extension of the coil principle of construction to guns heavier than any that had been hitherto known, was a perfectly safe step.

Since that date we have continued to advance in this direction, and the number of our heavy muzzle-loading rifled guns is now nearly as follows:—

7-inch gun of	6½ tons			576
7	"	7	"	113
8	"	9	"	119
9	"	12	"	465
10	"	18	"	26
12	"	25	"	25
12	"	30	"	11
13	"	23	"	3
			Total......	1338

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* See "Return of all Whitworth Guns, &c." ordered by the House of Commons to be printed, 10th August, 1866.

† The weakness of the vent-piece is no argument against the strength of the body of the gun. One of these 100-prs. of 4 tons weight withstood perhaps the most extraordinary test of endurance ever applied, viz. one hundred rounds with 14 lb. powder; the first ten rounds with shot of 100 lb., the second ten with shot of 200 lb., and so on until the last ten, when shot of 1000 lb. were employed. These 1000 lb. projectiles were 8 ft. 8 in. long, and projected 2 ft. beyond the muzzle of the gun.—See "Ordnance Blue-Book" of 1863, p. 214, question 4438.

The number of rounds fired from service guns of the coil construction must now be counted by hundreds of thousands.

Of the 9-inch guns alone there are seven that have all fired from 500 to 707 rounds with battering charges of 43 lb. of powder, three of them having fired over 1000 rounds each of all kinds.

The experimental firing at Shoeburyness has, in a great measure, consisted of trials of the service guns; and it may give some idea of the extent of these trials to state that more than 50 tons of gunpowder has been expended there annually in this manner.

The essential feature of the Whitworth gun is the polygonal rifling, and for several years after Sir J. Whitworth's adoption of this mode of rifling, it appears to have been the only peculiarity in the guns by which they were entitled to bear his name. Thus we find that from 1856 to 1858 all the Whitworth guns tried by the Government were made of either brass or cast-iron, the blocks from which they were bored being those in ordinary use for smooth-bore guns; and it is therefore clear that at that time there was no claim to originality or invention, as regarded either the material or the method of construction of the guns.

Of these guns, the cast-iron ones, three in number, all burst, the most enduring of them lasting out only fourteen rounds; the brass ones were found to deteriorate by the expansion, and roughing or erosion of the bore, as well as by the wearing away of the angles of the rifling. The greatest number of rounds fired from any one of them was 460 from a 12-pr., when it became unserviceable, the bore having expanded more than one-tenth of an inch, and there being a large flaw in the bore half an inch deep.

In 1862 a further trial of four brass 12-prs. was made, each of them firing 200 rounds, after which they were all reported unserviceable.

The first Whitworth gun of compound construction made its appearance in 1859. It was an 80-pr. breech-loading gun, made with wrought-iron coils outside a steel tube—that is, on the principle advocated by Sir W. Armstrong—but the breech-loading arrangement was Sir J. Whitworth's. The projectiles weighed from 68 lb. to 71 lb. each. Forty rounds were fired from it before it was purchased by the War Department. Only thirty-five rounds were fired from it at Woolwich, when it became unserviceable. The outer coil had shifted. There was a serious fracture in the inner cylinder, about 30 inches long and of considerable depth. There was great difficulty in opening or closing the breech, and the vent was completely closed after fourteen rounds.

In the following year a 12-pr. breech-loader made of homogeneous metal was tried. It fired in all 289 rounds at different times, the last date of firing being in September, 1865, when the breech-closing arrangement was blown off.

These are the only two Whitworth breech-loaders of which we have any knowledge. Sir Joseph appears after their failure to have confined his attention altogether to muzzle-loaders. After this we find in 1861 an account of four 70-pr. muzzle-loading guns, of which two were made wholly at the Royal Gun Factories on the coil system, while the other two had barrels of Sir J. Whitworth's homogeneous metal, hooped with coiled wrought-iron tubes supplied from Woolwich. No conclusive trial appears to have been made of these guns. One fired 279 rounds, and was then converted into a service or Woolwich gun. Another split its barrel of homogeneous metal at the second round of proof; the third only fired fifteen rounds; and the fourth has never been fired. In 1862 a 7-inch muzzle-loading gun was tried. It was made at Woolwich of coiled wrought-iron over a forged-iron barrel. Only nineteen rounds were fired from it. Although not then reported unserviceable, there was a large flaw in the bore, considerable enlargement of the bore about the seat of the shot, and the angles of the rifling were much worn. (See Return, &c., 1866, p. 4.)

In the years 1864–5 the Whitworth Ordnance Company supplied the Government with six steel 1-pr. muzzle-loading guns for mountain service. Their projectiles attained a great range, but from their diminutiveness could only be considered in the light of playthings; and it may safely be said that purchase of such weapons was never recommended by any professional officer, naval or military. One was fired 122 rounds experimentally, and two more were issued to Her Majesty's ship *Basilisk*, but there appears to be no record of their performances. In 1863–5 came the Armstrong-Whitworth Committee, whose report occupies, with the appendices, 666 pages. This Committee was supplied with six Whitworth muzzle-loading guns, three being 12-prs. and three 70-prs. They were all made of Sir J. Whitworth's "homogeneous metal."

These guns, produced in 1864, may be considered the earliest guns which, in the three particulars of material, construction, and method of rifling, embodied Sir Joseph Whitworth's artillery principles; and the great delay (above a year) that took place in their delivery, shows that the Whitworth Ordnance Company had at that time great difficulty in producing reliable guns of even this comparatively small size.

They were tried most thoroughly, and showed great powers of endurance and other good qualities. One of the 70-prs. fired the large number of 3033 rounds without even then breaking up, although it was only held together by the outer hoop, and one of the 12-prs. withstood 2804 rounds, when it burst into eleven pieces. The Armstrong guns, both muzzle-loading and breech-loading, tested in competition with the Whitworth guns, endured the same amount of firing with even less injury, and in particular neither of the Armstrong 12-prs. failed by bursting.

The Committee reported upon the guns under their consideration, dividing the subject under twelve different heads, ten or eleven of which immediately concerned the guns, and the remainder the ammunition.

With varying advantages, ranged under so many heads, the partisans of either side naturally attach the greatest importance to the particular qualities in which their guns excelled. And thus, when relative values are assigned by the authorities to particular qualifications, and as a consequence one system preferred, on the whole, to the other, they who so decide do not escape the imputation of prejudice.

However this may be, it is certain that the report of the Armstrong-

Whitworth Committee was not sufficiently favourable to the Whitworth system to induce the Government of the day to adopt it.*

We next learn that, in 1865, a 7-inch Whitworth gun was ordered by the War Department at the request of the Admiralty. This gun is the first Whitworth gun which can be considered as capable of being used against iron-plated ships.

It was proved at Woolwich in July, 1866. The gun was then tried on board Her Majesty's ship *Excellent.* 385 rounds were fired, with shot or shell, during which the projectile four times jammed in the process of loading, and the gun was temporarily disabled—that is to say, the charge had to be destroyed by the continued application of water, and the shot or shell had to be blown out the following day with a small charge introduced through the vent. This jamming of the projectile in loading was considered as strong evidence against the system of rifling, but Sir J. Whitworth urged that the projectiles had not been properly prepared for use by scraping off the coating of paint with which they were covered when supplied. A further trial was therefore made with 150 empty shells and 150 solid shot, the diameters of which were slightly reduced to prevent the recurrence of the jamming. Notwithstanding this precaution, the same defect was observed, although not to the same extent, "difficulty" having been experienced in loading eighteen out of the 300 projectiles.

The Government also purchased a 9-inch Whitworth gun, which is now undergoing trial.

Summarising, we find that the Government have knowledge of thirty-eight Whitworth guns. As to eleven of them, there is no record of their use; so that we have only the meagre experience of twenty-seven heterogeneous guns, varying in size from the six 1-prs. to the 300-pr., including both breech-loaders and muzzle-loaders, and constructed, some of brass, some of cast-iron, some of wrought-iron in various combinations, some of homogeneous metal, and of ordinary steel.

As regards the material of the gun, Sir J. Whitworth prefers steel for the entire structure, while Sir W. Armstrong has, from the first, advocated the use of coiled wrought-iron with a steel inner barrel.

Now, it is remarkable that the steel barrel, or lining, has always been the weak point of the service guns, and has invariably proved to be the first part to fail, whereas the coiled iron superstructure has often held the gun together long after the steel had given way; so that the proposal to extend the use of steel to the superstructure of the gun, amounts to being a proposal to abandon what has been always found the most trustworthy material, and rely upon what has been always found the most capricious. However this may be, the very great experience that we have had of coiled wrought-iron guns of all sizes, is an ample proof of the sufficiency of their strength. The material is

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* A return of all the rounds fired from Whitworth guns up to the 30th April, 1866, appears summarised in a tabular statement under the head "Whitworth Guns," ordered to be printed by the House of Commons, 10th August, 1866, and from this return the above account has been principally derived. A more recent paper, under the same head, was printed for the House of Commons, 6th June, 1867, and from this is completed the authentic history of the Whitworth guns.

notoriously cheaper than any kind of steel, and it has the fortunate property of bulging before it bursts; thus giving warning to the gunners when a gun is near the end of its existence, whereas steel will up to the last round preserve a delusive appearance of unimpaired strength.

Steel is advocated by Sir J. Whitworth on account of its greater tensile strength; but this, its undeniable property, has not yet been proved by the infallible test of experience to afford a safe criterion of its superiority for artillery purposes.

There are, indeed, some kinds of strain that wrought-iron is better able to withstand than steel; and although it would be premature to state positively that the strain on the body of a gun is of such a nature, there are nevertheless some grounds for supposing so.

It has been proved by trial that steel armour-plates are easier of penetration than plates of wrought-iron; and, indeed, various combinations of steel with wrought-iron have also been tried, but have all proved a complete failure as compared with the simple wrought-iron plate. Here, then, is an example of a strain which steel is less capable of supporting than wrought-iron, and it is to be observed that the strain on a gun is of a like sudden nature.

But a direct objection to steel is its uncertainty. It is difficult to obtain uniformity, either in its quality or its temper, and when manufactured there are no means of deciding upon either of these points except by the destruction of the gun.

An example of the difficulty in judging of metal when in a manufactured state, is to be found in the case of one of the Whitworth 12-prs. tried by the Armstrong-Whitworth Committee. Sir J. Whitworth, in his evidence before that Committee, 7th February, 1865—questions 3724 and 3862—twice stated that these guns were made of "homogeneous metal," but in one which had been destroyed it was found, by subsequent analysis, that the trunnion ring and trunnions were of wrought-iron (see question 3860, p. 145), so that he was in fact ignorant of the metal of which an outside portion of one of his own competitive guns consisted, although made in his own factory.

Thus it happened that, in his own estimation and in that of the Committee, the performance of a piece of wrought-iron was credited to "homogeneous metal;" nor would the error have been discovered but for the destruction of the gun, when the appearance of the fracture revealed the fact.

Of the danger and uncertainty of steel we have ample evidence, both in this and other countries, and it must be borne in mind that the failure of steel in small guns is an *à fortiori* argument against its use in large guns, and secondly, that these failures have occurred in a comparatively insignificant experience of steel ordnance.

In June, 1860, a puddled-steel 12-pr., made by the Mersey Steel and Iron Works, burst at Shoeburyness at the sixth round.

In June, 1861, a 7-inch steel gun by the same makers burst at the sixteenth round; while in November of the same year a 20-pr. Krupp gun burst at the second round.

In March, 1862, a French 30-pr. steel gun burst at Gavres.

In August, 1865, a Krupp 9¾-inch steel gun burst with a moderate charge of powder, a Prussian committee attributing the failure to inferiority of the metal. In Russia, during the same year, a 9½-inch gun of Krupp's steel burst at the sixty-sixth round, and an 8½-inch similar gun burst at the ninety-sixth round.

In June or July, 1866, a 9-inch Krupp gun burst in Russia at the fifty-sixth round; while in the same year a field gun by the same maker burst at Berlin, killing three cadets.

During the Prussian campaign against Austria in 1866, six Prussian steel field guns burst.

In January, 1867, a 7-inch Krupp gun burst at the second round of proof at Woolwich; and in the same year a 4-pr. burst at Tezel, near Berlin, killing two men.

In 1868, an 8-inch Krupp gun burst on board a Russian frigate very destructively, killing and wounding in all twelve men.

In 1869 (January 27th), a similar gun burst in Prussia into twenty pieces.

Besides these guns, large guns constructed of steel, supplied either by Krupp or Petin and Gaudet, have burst violently at Madrid and Turin.

The admitted caprice of steel has always led Sir J. Whitworth to propose a special steel for his guns, and for testing the quality of which he relies upon special methods peculiar to himself, of which the results only, and not the actual experiments made, are known.

Thus, in 1863, he advocated "homogeneous metal" with great earnestness, and after many private trials, the results of which were declared conclusive in its favour. But this metal never came into use, and has now dropped completely out of sight, so that we may be allowed to rank it, as regards uncertainty and danger for ordnance use, with other descriptions of steel.

But Sir J. Whitworth now believes that "Whitworth metal," or "compressed steel," will meet all his requirements; and for the last three years and a half this material has undergone the same process of private experiment and of introduction to the authorities that was formerly practised for "homogeneous metal."

If it really possessed the superior qualities ascribed to it, its money success for commercial purposes would be immense and already assured, and three years and a half would have proved a sufficient time to bring it into use; at present, however, there is no evidence of its being regarded with greater favour by manufacturers and engineers than the old "homogeneous metal."

The Government has repeatedly applied to Sir J. Whitworth for gun-tubes of this "compressed" metal, but the application has been persistently declined.

In fact, Sir Joseph has made it to be clearly understood that a trial of his new metal, of the value of which we have no independent practical guarantee or experience, can only be accorded to the Government on the condition of their undertaking to reconsider the old questions as to the merit of Whitworth rifling and Whitworth projectiles.

The Whitworth rifling is polygonal, the transverse section of the bore being a hexagon with the angles rounded off, and the projectile is either cast or planed to fit the bore, leaving a small windage. The body of the shot is therefore in immediate contact with the bore of the gun, both while loading and firing.

In the service or "Woolwich" rifling, helical grooves are cut in the cylindrical surface of the bore, and the projectile is armed with studs or buttons of soft metal, which fit the grooves and project to such a distance from the body of the shot as to prevent its surface from coming in contact with that of the bore.

The principle involved is therefore generally described as that of "soft-metal bearings." This principle is common to many other systems of rifling—as, for example, Sir W. Armstrong's shunt, the French, Captain Scott's, &c. In such methods, the whole work, both of guiding and spinning the shot, is thrown upon the projections on the shot and the grooves of the gun, the bore proper serving only to confine the elastic gas produced by the gunpowder.

The principal advantage claimed for the Whitworth system, is the simplicity and cheapness of the projectile. Special virtues have also been attributed to it, though perhaps not by Sir J. Whitworth himself;* 1st, as producing great range and accuracy, and 2nd, penetrative effect at long ranges. These are, however, due to smallness of bore, and are not at all peculiar to polygonal rifling. As regards the first, it will be useful to notice what has happened in the case of small-arms.

It is notorious that to Sir J. Whitworth is due the determination of the proper calibre and degree of rifle-twist for a bullet of 530 grains. His calibre and twist have been substantially adopted by all good gunmakers and rifle-shots in this country, but the polygonal rifling has been abandoned. In the last International Competition at Wimbledon for the Elcho Challenge Shield, in which twenty-four competitors were engaged, not a single Whitworth rifle was used; and in the same competition of the preceding year, only one was used, the score made with which was the worst of the whole twenty-four.

But the objections to polygonal rifling for guns are far more decided than for small-arms, where a soft lead bullet is used.

In the case of guns, the projectile has been found liable to jam in the bore while loading, as instanced in the trial of the 7-inch 7-ton gun at Portsmouth, already referred to; and it is known, from confidential official reports to the Foreign Office, that the same defect was observed by the Brazilians, who used several Whitworth guns during their recent war with Paraguay.

This jamming also occurred in the case of two 80-pr. Whitworth guns used during the American war, in the attack on Charleston, August, 1863. (See Appendix IV. to "Correspondence, &c." 1867.)

Such a defect is of itself sufficiently serious to condemn the system, whatever may be the advantages claimed as regards simplicity and cheapness of projectile.

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* Before the Ordnance Committee of 1863, Sir J. Whitworth stated:—"There are many forms of rifling, which, if the gun is kept clean, will shoot well if it be accurately made; and those who have a knowledge of accuracy of measurement and of true surface may make rifle guns shoot well with various forms of rifling."—See "Blue-Book," p. 106, question 2454.

But the strain also, on both gun and projectile, is greater than in any of the "soft-metal-bearing" systems, and this produces a liability of the shell to break up in the gun.

This accident happened seven times during the trial of the Whitworth 7-inch gun on board the *Excellent* (see "Correspondence, &c." 1867, pp. 29–33), and seventeen times in 150 rounds of shrapnel fired by the Armstrong-Whitworth Committee from the Whitworth 70-pr. (see their Report, 1866, pp. 405–7). It is also described as having repeatedly and constantly occurred with the two 80-pr. Whitworth guns used against Charleston (see "Correspondence, &c." p. 22); and after this experience of the liability, we find the same thing happening again in a 9-inch Whitworth gun of 14½ tons, fired at Shoeburyness so recently as March 2nd, the shell being made of the very "Whitworth metal," from which we are invited to anticipate so much.

Lastly, the hard projectile is found to wear away the surface of the bore.

The most striking demonstration of the superiority of the "soft-metal bearings," as regards the durability of the bore, is to be found in the brass rifled field-gun recently adopted for service in India, which may fairly be compared with any of the brass guns formerly rifled on the Whitworth system. One of these Indian guns, with grooved rifling and studded projectiles, has fired 2700 rounds, and a considerable length of the bore from the muzzle inwards is still perfectly sound; whereas, of the brass Whitworth 12-prs. already mentioned, the bore of one was found to be expanded more than a tenth of an inch, with other injuries, after only 460 rounds, and the four other guns became unserviceable after no more than 200 rounds. It is therefore clear that, *cæteris paribus*, the Whitworth rifling is more damaging to the bore of a gun than service rifling.

Sir J. Whitworth advocates a flat-headed steel projectile for penetrating iron plates, and more especially for piercing them at oblique angles of impact; for general purposes of other kinds, he uses a more or less pointed head.

The service projectiles are pointed for all purposes, those for use against iron plates being the well-known Palliser projectiles of chilled iron with sharp ogival points.

The only noticeable difference in form of head or material between the two systems, is therefore to be found in the armour-piercing projectiles.

This question, like those of twist and calibre, is quite independent of the material or rifling of the gun, but we have some evidence of the comparative merits of the specialities advocated by Sir J. Whitworth.

During the competitive trial of Armstrong and Whitworth 70-prs. in 1865, three rounds were fired at 200 yards range from each gun with steel projectiles against 4½-inch iron plates, thrown back at an angle of 38° from the vertical. The heads of the Whitworth shot were flat, and those of the Armstrong hemispherical.

There was a marked superiority in the effects of the round-headed Armstrong shot in all three instances; but the experiment was not conclusive as regards form of head, because the calibres of the guns were different, the larger bore of the Armstrong gun enabling it to burn 14 lb. of powder, while the Whitworth could only use 12 lb. effectually. On the other hand, the large diameter of the Armstrong projectile was adverse to its penetration, as compared with the smaller diameter of the Whitworth shot. The much greater effects of the Armstrong shot, although they did not establish the superiority of the rounded head, yet tended to dispel the illusion that there was any special virtue in the flat form; and it was noticeable that the round head did not glance more than the flat one, but bit well into the plate, in one case showing daylight through a hole in the plate 2 inches square.

This experiment has value incidentally, as illustrating the uselessness of attempting to arrive at a definite conclusion upon any one issue when others are largely mixed up and confused with it.

Many shots, both pointed and flat, were subsequently fired, from time to time, direct against iron plates. A list of such shots as, from the similarity of other conditions, were fairly comparable, is to be found in the Parliamentary papers already referred to—viz. "Correspondence, &c." p. 22; and the conclusions which the Ordnance Select Committee drew from their comparison (in the 8th paragraph of their Report, p. 14 of papers above), are not in favour of the flat head.

In October, 1866, we have further evidence. Six comparative rounds were fired with Palliser chilled shot and shell, and Whitworth flat-headed steel shot, the former weighing 115½ lb. and the latter 113 lb.; their diameters were alike, and their penetrative powers, as expressed by the "work per inch of shots' circumference," were very nearly the same.*

The first pair of rounds were fired direct, and the remainder at an angle of 33° from direct impact.

The results were largely in favour of the Palliser pointed heads; and it was noticeable that, so far from these latter having a tendency to glance off the plate, as argued by the supporters of the flat head, on the contrary they turned inwards, so as to improve the direction of the shot for penetration.

Here terminates the record of War Office experience, which is altogether adverse to the flat heads; the more so as Capt. W. H. Noble, R.A., has found by experiment that, with velocities of about 1100 ft. per second, the loss of velocity of the flat head, due to the resistance of the air, is to the corresponding loss of the pointed head as 113 to 63—a ratio which becomes more unfavourable for the flat head as the velocity is higher, and less unfavourable when lower, than 1100 ft. per second. This result has been questioned by Sir J. Whitworth, who, strange to say, proposes to estimate the comparative loss of velocity by the difference between the extreme ranges of the two forms of projectile.

The fact is, that long before either projectile attains its extreme

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* The War Office record numbers of the rounds are:—

Steel flat-head	No. 1235	1234	1263
Pointed "Palliser" ...	No. 1248	1245	1258

range, its velocity is of course very low, and therefore the disadvantage to the flat head cannot be so apparent. But since neither projectile would be effective against armour-plates with such low velocity, it follows that this part of its flight should not be included in the calculation. The flat head is really at great disadvantage from its greater loss of velocity when moving at any effective speed.

Besides official experience, we have the record of some private experiments of Sir J. Whitworth, of which an account was read before the British Association at Exeter, in August, 1869. They were made with a gun of only 1·85 inches calibre against plates from 1½ to 2 inches thick. The conclusions are directly opposed to those to which all official trials have pointed, and this disagreement remains to be accounted for; but in estimating the values of the opposed conclusions, it must be remembered that the official results were obtained with real guns of 5½-inch and 7-inch calibre firing against real armour-plates, both backed and unbacked, and not, as in the case of Sir J. Whitworth, with a toy gun of 1·85 inch bore.

Besides, his experiments seem to have been wanting in philosophical method. Sir Joseph fell into the error of mixing up the two questions of material and form of head, which might easily and should certainly have been kept distinct, especially in the case of such a small gun as he was using.

This is far from being a solitary instance of want of perspicuousness in Sir J. Whitworth's method of experiment; and the liability to errors of this nature ought to throw some doubt on private tests and trials carried out by inventors themselves, and through their own dependents. In fact, it would certainly seem that artillerists, however able, have more to gain than to lose by perfect openness, both as regards their views and the experiments upon which those views are based.

That artillerists of great distinction may blunder, is clear.

Sir Joseph himself once entertained the idea, and possibly continues to do so, that the "initial velocity of a spherical shot from a smooth-bored gun, would not be as great as from a spherical shot from a rifled gun." (See "Ordnance Blue-Book" of 1863, p. 102, question 2350.)

He learned from official records that the initial velocity of the service 12-pr. round shot was about 1900 feet per second; he therefore proposed to the Director of Ordnance to fire a sphere from his own 12-pr. rifled gun, which was accordingly done, and the unprecedented velocity of 2200 feet per second was obtained. He was thereupon satisfied that the increase of 300 feet was due to the rifling alone (see "Blue-Book," p. 106, questions 2460–61). It is needless to say that this conclusion should never have been accepted for a moment. Upon such premises one might shew that, since a rifle-twist of one turn in twenty calibres gave an increase of velocity of 300 feet per second, a twist of one turn in every calibre would give a much greater increase, and that with such simple means at our command of increasing velocity, powder might be economised, and we should ultimately arrive at a gun which would require no powder at all, but would "go off" by sheer twist of rifling alone.

The facts are, that the shot whose velocity was assumed to be 1900 feet per second weighed over 12½ lb., was about 4½ inches in diameter, and was fired with 4 lb. powder, while the rifled sphere weighed less than 3½ lb., was less than 3 inches in diameter, and was fired with 1¼ lb. powder. The lengths of the bores of the two guns were in totally different proportion to their diameters, the windages were different, and the descriptions of powder also different.

So that there were actually six independent causes of variation in the velocity besides the one of smooth and rifled barrels, all of which were either overlooked or ignored by Sir Joseph Whitworth.

And yet, from the circumstance of both guns being called 12-prs., his argument at p. 106 of the "Blue-Book" appears plausible enough, and no doubt convinced others as well as himself.

To recapitulate. We are threatened with a fresh trial of the Whitworth system of guns, rifling, and projectiles in the shape of a 35-ton gun—a size nearly one-half larger than any gun hitherto completed in this country, and about three times the size of any as yet constructed by Sir J. Whitworth.

This trial is partly induced by the unsatisfactory mutual relations of the Amiralty and War Office.

The expense will be great, but a much stronger argument against the trial is the heavy drag which it will prove to our scientific artillery progress.

Several instances have been cited showing the difficulties which have been encountered in trying to decide questions when they have, by injudicious process of experiment, become entangled with others.

The existing heavy guns of the service, up to 25 tons weight, have been most extensively tried, and have proved eminently successful, as regards strength and durability, range and accuracy, as well as in their power of piercing armour-plates.

They are approved of in both services, and the professional advisers of the Admiralty and War Department do not ask for an alternative system.

On the other hand, the trials of the Whitworth system present a mass of failure, with here and there a few instances of success. In the most important feature, the structure of the gun, it has always been a following, not a leading system. Thus, when the Whitworth manufacture had reached the stage of a 4-ton gun, others had, by a steady increase from size to size, attained the magnitude of a 22-ton gun; and it is also noticeable that to this day the four heavier natures of Whitworth guns as advertised have never been tried, being in fact only paper guns.

The system has been tried abroad, both in Europe and America, in actual service, and has failed in the same manner as at home.

The professional advisers of the Admiralty and War Department concur in its rejection.

And yet it is seriously proposed to try a Whitworth 35-ton gun, because Sir J. Whitworth has invented a new metal which, from his private and special experiments, appears likely to prove a great success, and is therefore worthy of trial.

The obvious course to pursue, if the metal must be tried, is to advance, step by step, from the doubtful experiments of Sir J. Whitworth, and to test it in the shape of tubes for 5½-inch or 7-inch guns, and if successful, to go still farther; but to advance *per saltum* to a complete gun of 35 tons, complicating the question at the same time with others of construction, rifling, projectiles, rear-vent, patent cartridges, and so forth, would be as mischievous to practical artillery progress as it is indefensible on scientific grounds.

THE FIELD GUN FOR INDIA.

A PAPER READ AT THE R.A. INSTITUTION, WOOLWICH, FEBRUARY 22, 1870,

BY

COLONEL H. H. MAXWELL, R.A.

MAJOR-GENERAL F. M. EARDLEY-WILMOT, R.A. IN THE CHAIR.

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1. UP to the year 1862, the armament of the Indian Field Artillery consisted of 9 and 6-pr. guns, and 24 and 12-pr. howitzers. The field battery pieces were lighter than those in use in England, weighing only 10 cwt. The horse artillery pieces were identical with those of the home service.

About that date the first breech-loading Armstrong battery reached India. I can tell you little from my own personal knowledge of the efficiency of the guns in that country, as the superintendence of the Indian Gun Foundry fell to my charge at the same period. Gradually I came in contact with them in another way. All sorts of strange things came into my hands, sent to me as patterns for manufacture, of whose use I had only read. But at last, a 6-pr. breech-loader Armstrong gun, split in the powder-chamber, came to me for repair, if possible. With a feeling of despair I was compelled to return it, with an intimation that its repair was beyond my power.

Chance threw in my way, in 1865, a description of the French field gun, and at the same time I learnt that it had been tried at Shoeburyness, and that its practice was found equal to that of the 9-pr. breech-loader of the service.

I heard, too, that the Dutch in Java had adopted the French system, and manufactured the guns and their equipments on the spot.

I came to the conclusion that a gun of this description was precisely what we wanted in India, as we had an ample stock of bronze in the country. I appealed to the powers that be; my proposals were favourably received, and were sent to England for submission to the Ordnance Select Committee, who reported not unfavourably of them.

Just at this time the Armstrong and Whitworth controversy had been fought out on the sands of Shoeburyness. Muzzle-loaders began to hold up their heads, the navy especially objecting to breech-loaders. The next step in the history, was the assembly of a Committee of superior officers of artillery; they reported unanimously in favour of muzzle-loading field guns.

Then followed experiments with steel-barrelled iron-coiled guns and a bronze gun of the same size and shape. The experiments were so far unsuccessful, that these guns were beaten by the service breech-loaders in accuracy. The poor bronze gun soon gave in, after having been treated to a few shells with cast-iron ribs, which struck out a line of rifling for themselves.

Finally, in December, 1868, a Special Committee was appointed under the presidency of Major-General F. M. Eardley-Wilmot, R.A., on the Equipment of Field Artillery for India.

I feel sure, in mentioning General Wilmot's name as President, that the recommendations of the Committee will derive additional weight in the minds of those now present. After a long series of experiments, that Committee proposed the adoption of a muzzle-loading 9-pr. bronze gun of 8 cwt. as the sole gun for the horse artillery and ordinary field batteries in India. The gun has been so far adopted into the service, that the 9th Brigade of field artillery is about to be armed with it. To give you some idea of the piece and of its powers, is my object in addressing you this afternoon.

2. Until within the past year there existed, and perhaps exists still, in the minds of many artillerymen, a somewhat ill-defined impression that a breech-loader *must* shoot better than a muzzle-loader. I, for one, hold that this is by no means the case. The muzzle-loading small-arm rifle is in nowise inferior to the breech-loader in accuracy. Why should the reverse be the case with guns?

I may be told that in the breech-loader the non-existence of windage is sufficient to demonstrate that it must shoot better than a gun with windage. I demur. I say, if I can centre a muzzle-loading projectile, and keep it centred as it passes along the bore, I shall have at least as fair a chance of making a good shot as the breech-loader, which at best can only do the same.

But to quit theory and to come to facts. What is the result of actual practice? Why, simply that as regards accuracy and uniformity of range, there is little difference between the two systems.

If *greater* accuracy, then, is no longer allowed to be the peculiarity of breech-loaders for field guns, that system, according to my lights, has not a leg to stand on. For we know, as regards rapidity of firing, that there is no advantage one way or the other.

I do not think I have ever seen the matter better put than in the Professional Tour Report of the Royal Artillery Officers who visited Russia in 1862; it was in these words:—

> "The Russians are generally opposed to breech-loading for all services, as being unnecessary in the field, and impossible for large charges and heavy guns."

That is, just where they would be useful, they fail; and where they would be of no especial service, they may be used by those who like complication.

I have been told that the Russians have gone back from this wholesome doctrine, and have taken to the complications they formerly believed to be unnecessary. I confess, in one sense, I am sorry for the Russians, as I firmly believe they have some bitter experience to buy

Fig 3.

a. Driving side
b. Loading side

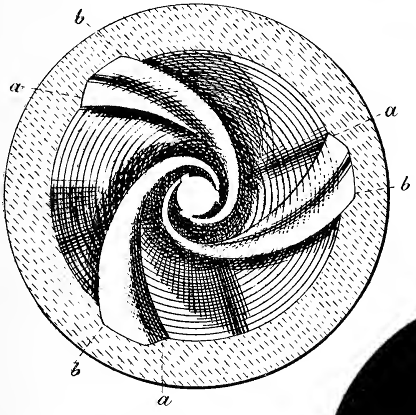

Fig 2.

Fig 1.

Fig 4.

Lithographed at the Royal Artillery Institution.

in the matter. They have been frightened by a bugbear. They held that bronze was too soft to stand the wear of rifled projectiles, and that if the metal of the studs were softer than that of the gun—perhaps the only condition upon which the guns could stand the wear—the studs would be knocked to pieces in travelling.

3. The French, at the outset of their experiments, got deplorable results from their bronze muzzle-loading guns. As the shell lay at the lower surface of the bottom of the bore, the cast-iron was in contact with the gun-metal; the stud was used merely to compel the shell to follow the twist of the groove, and not to protect the bronze of the bore from the cast-iron. What was the consequence? The windage or space between shell and gun being at the upper surface of the shell, on the explosion of the charge, the upper edge of the base of the shell struck the top of the bore, while the shoulder of the shell was hammered down on to the lower surface. This sectional diagram will perhaps illustrate the effect. You see that the shell did its best to revolve round its shortest axis, and you may imagine how a shell thus started behaved itself as it passed along the bore. It was about on a par with the old round shot, and some fifty rounds rendered the gun unserviceable.

Enlightened by this misconduct, they made the studs project farther beyond the surface of the shell, so that when it lay as before, at the lower surface of the bottom of the bore, there was a clearance between cast-iron and bronze.* The gun was thus subject to the friction between the zinc of the stud and the bronze of the driving sides of the grooves. Under these conditions the guns shot well and endured long.

The Austrians having suffered under these guns in 1859 in Italy, studied the matter, and in 1863 introduced a centering system applied to muzzle-loading guns. The diagram† will give you an idea of that system. The projectiles are formed of a similar figure to, but of a slightly smaller diameter than the bore of the gun, and are covered with a coating of an alloy of tin and zinc. This alloy being softer than bronze, the friction between the two metals is favourable to the latter in point of wear; but owing I suppose to the sharp angles of the surface of the alloy, each projectile has to be carried well greased in a canvas bag in the ammunition boxes. This appears to me to be the defect of the arrangement.

The French guns fire between two and three thousand rounds with satisfactory practice to the last. The Austrian guns fire some 1500 rounds, after which service they are recast.

I have thus shown you, I hope, how a projectile composed of the hard metal, cast-iron, can by a little artifice be fired from a gun made of a comparatively soft metal like bronze. It is, in short, by isolating the cast-iron from the bronze.

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* Vide Fig. 1.

† Vide Fig. 4, representing a vertical cross section through the gun and shell, the latter lying at the lower surface of the bore. When centred, the windage forms six lozenge-shaped figures when seen in section.

4. But the metal of the gun has more to stand than the mere friction of the studs of the projectile; it has *first* to sustain the expansive force, and *second*, the great heat of the powder gas.

Now, as to the first point—the expansive force—I believe there is no known metal or combination of metals which gives such absolute security from bursting as bronze. It is not that an individual steel gun, with or without wrought-iron coils, may not be stronger perhaps than an individual bronze gun of the same size; but take 1000 bronze guns, and you may be perfectly certain that not one will burst. It remains to be seen if the same is the case with steel guns, with or without wrought-iron coils.

The Prussian Ordnance Committee made some interesting experiments on the resistance of bronze. The guns used were the 4-pr. and 6-pr. The former fires a shell of about 9 lbs. weight, while the gun weighs about 6 cwt., and the latter a shell of about 15 lbs., with a weight of gun of 9 cwt.

I will confine myself to the former. They turned down the gun of 6 cwt., a small quantity at a time, until it weighed only 2 cwt., the thickness at the breech being reduced from 2·4″ to 0·8″, and at the muzzle from 1″ to $\frac{1}{4}$″. With this gun they made a series of experiments, firing a 9 lb. shell with a charge a little over 1 lb. After each series, the bore was examined to find out where expansion first took place. It was only after the thickness at the seat of the charge had been reduced below 1$\frac{1}{2}$ inches that expansion took place. Further, with this thickness, expansion took place after a few rounds and then ceased. When the gun was reduced to a thickness of under a $\frac{1}{4}$ of an inch, small cracks were observed through which the powder gas escaped; the gun was, however, fired with safety.

The heavier gun of 9 cwt., with a shell of 15 lbs. and a charge of 2$\frac{1}{5}$ lbs., when reduced to $\frac{2}{10}$ths inch thickness at the muzzle, burst, throwing a good large piece out of the chase with violence. Thus there was ample indication of approaching rupture.

Incidentally, I may mention that as the guns were reduced in weight, the charge of powder and weight of shell remaining the same, the guns were most destructive to their carriages; a circumstance which we all could have anticipated, but one involving a true principle of construction not sufficiently borne in mind, viz. heavy gun and light carriage. I shall have occasion to allude to this further by and by.

The resistance, then, of pure bronze guns, much below the ordinary thickness, gives ample safety from bursting; while that of guns of the ordinary dimensions is so great, that it is almost if not quite impossible to burst them. To destroy them, the shortest plan is to heat them to redness, and then attack them with a sledge-hammer. Under this treatment they tumble to pieces in a surprising manner.

This statement naturally leads us to the second point—how do bronze guns resist the great heat developed by the combustion of the powder?

On this point bronze is decidedly deficient; but fortunately in field guns the amount of powder burnt in each charge is small, and the scoring or erosion consequently of little importance. This scoring, moreover, is in nowise detrimental to the accuracy of the shooting, because the studs of the shell being locked hard against the driving sides of the grooves, there is an air-tight joint between them; hence no gas can pass. Thus, on examining the grooves of a bronze gun which has fired a large number of rounds, you find the lands, loading side and bottom of the grooves, pitted by the heat burning the tin out of the alloy, and eroding the metal; the driving sides, on the other hand, are perfectly free from such pitting.

One more source of injury to a bronze gun, consists in the effect of the accidental and premature explosion of a shell in the bore. Experiments at Shoeburyness with live common shells, having a small hole bored through the base, so as to form a direct communication between the charge in the gun and that in the shell, prove that no material injury is done to the gun beyond a few unimportant scratches.

5. In the present state of our knowledge, the choice of a metal or combination of metals for a field gun, appears to lie between steel, or steel protected by a wrought-iron coil, and bronze. Circumstances may have unduly prejudiced me, but I confess I think there is nothing like bronze for the roughing of a long campaign, nothing like it for simplicity of manufacture, nor for safety from bursting, nor, finally, for economy. It is curious to look back and to find that I am expressing an opinion held as far back as four and a half centuries. One Capo Bianco, publishing in 1598, states that there were bronze guns in existence in 1418.

Bronze, if bright from the turning-lathe, when exposed to damp air, soon oxidizes, and gradually attains the green brown tint so much admired in antique statues. After the film of oxide has penetrated to a certain depth, practically the action on the metal ceases, though the oxide itself gets a deeper tint by time. This is the explanation of the perfect condition of antique bronze statues, and other objects, which have been found in certain soils after having been buried for centuries.

With iron or steel, on the contrary, once oxidation has set in, it goes on with increased vigour, and eats away until the whole mass is finally oxidized.

This is why I say bronze is better suited for the roughing of a campaign than steel.

As to simplicity of manufacture, nothing can be simpler than the casting of the block, once you have got apparatus suited to the size of your gun.

Recollect in making a comparison as regards manufacture between bronze and steel guns, you must not confine yourselves to what you have seen done in the Royal Gun Factories, you must go to Mr. Firth's or to Sir Joseph Whitworth's factories, and watch the processes there. I will not detain you with an attempt to describe these processes. I will confine myself to the statement that the art of casting steel in large masses is in its infancy; that it is necessarily expensive, from the high melting point of the metal; and that, in the present state of our knowledge on the subject, it would not be advisable to attempt it in India.

As regards economy, the value of a new bronze gun of 6 or 8 cwt. is to the value of an old one in the ratio of 17 to 7. In other words, you recover £7 after using your bronze gun for a great number of years, out of every £17 you originally expended.

The value of a steel gun with wrought-iron coils of those weights when new, is greater than that of the corresponding bronze gun; and when old, it is worthless, or the next thing to it.

6. So much for the metal; let me now turn to the nature and weight of the field gun for India, first confining ourselves to horse artillery.

The nature and weight of gun for employment in that or in any other country, is best considered by first deciding on the following points:—

(1) What weight can your teams draw at the pace you propose to go?
(2) What is the least weight of projectile which will be efficient on explosion, and what is to be its velocity?
(3) How many rounds do you want with the gun and limber?

On some, if not on all of these points, artillerymen will differ: hence the problem will have a variety of solutions. Permit me to give you my ideas on them.

In India we find that a team of six horses can draw from 30 to 32 cwt. at the pace required for horse artillery.

On the second point, I consider that an explosive projectile, to be efficient, should not weigh under 9 lbs.

As to the quantity of ammunition with the gun and the limber, though opinions differ widely on the point, I think I shall not be far wrong in taking the same number of rounds as the 9-pr. breech-loading gun, viz. 34. At the same time, I should tell you that the French have lately increased the number of rounds with their gun and limber from 36 to 44, the alteration being due to the adoption of breech-loading fire-arms by the infantry.

Then as to velocity: your 12 and 9-pr. breech-loading guns fired at Dartmoor with velocities of 1121 and 1058 feet per second. This pace is slow as compared with that of the round shot of the S.B. 9-pr. with its 1614 f.s., or of the S.B. 6-pr. with its 1484 f.s.; the result is, that up to 700 or 800 yards the S.B. guns have the flatter trajectory. It seems to me clear, then, that if we wish to improve on the present breech-loaders, we must increase the velocity; but as we cannot hope to fire a projectile of 9 lbs. with such a velocity as 1600 feet from a horse artillery gun, let us see if we cannot manage to fire with 1400 feet—a velocity rather less than that of the 6-pr. round shot of the horse artillery gun.

I have thus roughly given answers on the three points:—

(1) 30 to 32 cwt. behind the gun team.
(2) A 9 lb. projectile with a velocity of 1400 feet per second.
(3) 34 rounds with gun and limber.

Let us see what these answers will lead us to.

As at present constructed, the lightest limber, without load, weighs 10 cwt. We have, further, thirty times 9 lbs., and its charge of $1\frac{3}{4}$ lb.

for 1400 feet velocity; this load, with fuzes, cartridge-bags, &c., will amount to 3 cwt.; the loaded limber, with its entrenching tools, and so forth, will thus weigh about 14 cwt.; deducting this weight from 30 cwt., the lowest limit of the total weight above laid down, will leave us only 16 cwt. for the gun and carriage.

Let us next compare the initial velocity of recoil of such a gun on its carriage, firing a 9 lb. projectile at a rate of 1400 feet per second, with that of the 12-pr. breech-loading gun of the service. An easy calculation gives the former at 7 feet per second, and the latter 6·2 feet per second.[*]

The recoil with the 12-pr. breech-loading gun at 6·2 feet per second is lively, and I think should not be much exceeded for both convenience in service and endurance of the carriage. 16 cwt. is then too light for a velocity of 1400 feet with a 9 lb. projectile.

Taking, then, 6·2 feet per second as about the highest admissible limit, we can determine the weight of the gun and carriage which will project a 9 lb. projectile with a velocity of 1400 feet. Calculation gives us 18 cwt.[†]

This weight, added to that of the loaded limber, 14 cwt., will give a total of 32 cwt.

If, then, you wish to have a gun with which errors in estimation of the distance are of less importance than with your present guns; if you want a gun which shall give you a more grazing fire than your present guns, approaching closely or being equal in this respect to the fire of the old smooth-bore guns up to 800 yards, and beyond that range much better—if, I say, you want these advantages, you must increase the velocity of your projectiles as much as possible; and this, with a velocity of 1400 feet involves a weight of gun and carriage of 18 cwt., and a total weight behind the gun-team of 32 cwt.

Cannot some of the weight of the *limber* be got rid of?

After a good deal of consideration and inquiry, I am reluctantly compelled to believe that no very great diminution is feasible, without injury to the efficiency of the system.

7. We have, then, 18 cwt. for the weight of the gun and carriage. What is to be the weight of the gun itself? It must be mainly decided by the weight of the carriage. If the latter can be brought down to 10 cwt., and yet have adequate strength, the gun may be

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[*] 9-pr. M.L.:—

$$\overset{\text{f. s.}}{x} \times \overset{\text{cwt.}}{16} \times 112 = \overset{\text{f. s.}}{1400} \times \overset{\text{lbs.}}{9}$$

$$x = 7 \text{ feet per second.}$$

12-pr. B.L.:—

$$x \times 20\tfrac{3}{4} \times 112 = 1239 \times 11{\cdot}75$$

$$x = 6{\cdot}2 \text{ feet per second.}$$

1239 f. s. was the velocity of the 12-pr. B.L. with the slack pressed powder.—Vide "Handbook for Field Service," 1867, p. 322.

$$\dagger\ \overset{\text{f. s.}}{6{\cdot}2} \times \overset{\text{cwt.}}{x} \times 112 = \overset{\text{f. s.}}{1400} \times \overset{\text{lbs.}}{9} \qquad x = \overset{\text{cwt.}}{18{\cdot}1}$$

8 cwt. That carriage must be strong enough to withstand the furious jolts it is subject to behind a team rushing to the front at a gallop; at the same time it must be recollected, that the heavier the gun the less the carriage will suffer in firing. The best possible ratio of weights of gun and carriage is a nice point, which only long experience can decide. I am well satisfied so far, that in the breech-loading guns of the service, the guns should be heavier and the carriages lighter, and that the ratio I have proposed is far preferable.

8. Finally, as to calibre. It has been found that to get the best shooting, the shell should be between two and three calibres long; at the same time, to be efficient when burst, it should have adequate capacity for containing bullets, segments, and powder. If you take 3 inches as the calibre for a 9 lb. projectile, you get very formidable segment and shrapnel, with, I think, sufficiently powerful common shell and case shot. If you take a larger calibre than 3 inches, the two latter projectiles would have a larger capacity, but the shooting of the explosive projectiles would be deteriorated. If you go below 3 inches, the capacity of the explosive projectiles would be lessened, with perhaps a slight gain in shooting. Small variations above and below 3 inches would probably make little difference, but if you were to go to 3·5″ or 2·5″ for a 9 lb. projectile, I think you would be wrong.

As an instance in point, the French field gun has a calibre of 3·4 inches, and weighs 6½ cwt.; it fires with a velocity of 1066 feet per second, and complaints are very justly made of its high trajectory.

9. The gun that I think we should adopt for the horse artillery in India, is a gun of about 8 cwt. of 3″ calibre, with thirty-four 9 lb. projectiles, with the gun and limber, and a total weight of 32 to 33 cwt. behind the team. This is the gun recommended by the Committee on Field Artillery Equipment for India.

The main points, it appears to me, on which this recommendation should meet with the approval of thoughtful artillerymen are: that on this system you have a sufficient number of projectiles, with a gun capable of projecting them with a very high velocity, involving a total weight behind the gun-team quite within the recognised limits for horse artillery.

10. I have prepared a table from various authorities, chiefly from Major Roerdansz'* pamphlet, giving the principal weights and dimensions of various horse artillery guns and their equipment. It is instructive to examine how the artillery of the powers of Europe differ as to the armament of that branch. The French and Austrians agree very closely; the gun of the latter being founded on the former. The English and the Prussians are in many respects alike, but the latter carry the largest number of rounds with the limber of all the artilleries of Europe, and are therefore more independent of their wagons. The Russian and the Indian gun systems are the absolute antithesis of each other.

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* Das gezogene vierpfündige Feldgeschütz v. R. Roerdansz, Berlin, 1865.

The Russian gun fires with a high trajectory, the Indian with a low trajectory. It appears to me that we have the best of it, on the whole.

Table of the principal Dimensions and Weights of various Horse Artillery Guns and their Equipment.*

	Prussian.	English.	French.	Austrian.	Russian.	Indian.
Weight of gun ....cwt.	5·4	6·5	6·5	5·2	6·4	8·1
Calibre ....in.	3·1	3	3·4	3·17	3·4	3
Weight of common shell (s) ....lbs.	9	8·5	8·9	8	12·5	9
Weight of charge of gun (p) .... 〃	1·1	1·125	1·21	1·1	1·35	1·75
Ratio $\frac{p}{s}$	$\frac{1}{8{\cdot}1}$	$\frac{1}{8}$	$\frac{1}{7{\cdot}4}$	$\frac{1}{7{\cdot}3}$	$\frac{1}{9{\cdot}3}$	$\frac{1}{5{\cdot}1}$
Initial velocity ....ft. per sec.	1184	1058	1066	1093	?	1381
Weight behind gun team ....cwt.	30·5	32	25·8	23·6	24·4	33·5 34·1
Weight per horse in gun team ...... 〃	5·1	5·2	6·4	5·9	6·1	5·7
No. of rounds in limber and with gun	49	34	44	39	18	34 40
No. of rounds per gun in limber and wagon	157	124	156	156	130	124 148
Diameter of wheels ....ft.	4 5	5	4·7	3·5 4·4	4	5

Comparative Practice Table of Horse Artillery Field Guns.

	Yards range.	Elevation.
		° ′
4-pr. French	2000	6 47
〃 Austrian	〃	6 47
〃 Prussian	〃	6 24
9-pr. English breech-loader..........	〃	6 1
12-pr. 〃 〃	〃	5 20
9-pr. Indian muzzle-loader	〃	4 22

11. I am aware, however, that some officers do not appreciate the value of a great velocity, and consequently of a flat trajectory, as highly as I do; indeed, I am told it has been seriously proposed to adopt a gun, ordinarily carried on a mule's back, the 7-pr. of 146 lbs., as the armament of the horse artillery, in preference to this 9-pr. of 8 cwt. This proposition needs only to be stated to an artilleryman to carry its condemnation on the face of it.

But if my hearers of the artillery will pardon my entering into a few elementary questions of their craft, I will endeavour to put this matter as clearly as I can to those who have not turned their attention to the subject.

The horse artillery gun is chiefly intended for firing at troops with projectiles containing either bullets or segments, which are released

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* A more detailed table will be found as an Appendix.

from their envelope by the bursting of the charge. This charge is just strong enough for that purpose, and yet not strong enough to give the contents of the projectile *much* lateral spread. Further, for these bullets or segments to fly any distance, and to have sufficient force to kill a man, the projectile at the moment of bursting must have considerable velocity.

Again, if projectiles would only fly perfectly horizontally through the air, there would be no difficulty in hitting an object at every round; unfortunately, that pestilent gravity persists in acting on the projectile; thus, the shorter time gravity can act on the shell while it is flying from the muzzle to the point hit—that is, the greater its velocity—the closer the path of the projectile approaches the straight line, and the easier it is to hit the object aimed at.

If, now, we compare the 7-pr. gun with the 9-pr. muzzle-loader, we find that the shell of the former leaves the piece with a velocity of 672 feet per second, while the initial velocity of the latter, with R.L.G. powder, is 1381 feet per second. The 9-pr. shell, after flying 2000 yards, will be still going at a considerably higher rate than 672 feet, the initial velocity of the 7-pr.

It will be seen that the 9-pr. shell starts with more than twice the velocity of the 7-pr.; the shell travels faster from the muzzle to the point hit; gravity having all the less time to act on it, the chances of hitting are increased *pro tanto;* while the bullets or segments of the 9-pr. shell, when released after a flight inside the shell of about 2400 yards, travel at the same pace as those of the 7-pr. shell if burst at the muzzle.

I need hardly remind you that a range of 2400 yards will cover the depth of any battle field.

I think I have shown that any comparison between these guns as to efficiency, is vastly in favour of the 9-pr. of 8 cwt.; and as I have shown, its weight is quite within the power of horse artillery teams.

12. As to the field batteries, what should be the nature of the gun?

I think it a good plan to see what others have done in this matter. The Prussians have two field guns, termed the 4 and 6-pr., which fire 9 lb. and 15 lb. projectiles—I will call them by their English denominations —with charges of $\frac{1}{9}$th and $\frac{1}{11}$th respectively, and consequently with high trajectories as compared with the Indian gun, which fires with a charge of $\frac{1}{5}$th. With reference to these pieces, the Prussian "Officers' Handbook" states that:—

> "The 9-pr., as regards practice, is in no way inferior to the 15-pr.; but it is obvious that an individual 15-pr. projectile must do greater damage on any fixed object which it may strike, such as a house, a wall, &c., than the 9-pr. For this reason, to cannonade such an object the 15-pr. would be preferable; whilst against troops, generally speaking, the one calibre has no advantage over the other. The sole advantage of the 15-pr. is the greater moral effect it has under certain circumstances. The advantages the 9-pr. has over the 15-pr. consists chiefly in the larger supply of ammunition, whereby the former is more independent of its wagons. Another advantage lies in the fact that its pace is faster, and can be longer kept up."

According to this view, the Indian 9-pr. will do all that is required of a field battery gun in the way of man-killing. I am satisfied that had the Prussians introduced their 9-pr. before the 15-pr., instead of the reverse, the 15-pr. would never have existed.

For the horse artillery and ordinary field batteries, then, the Indian Committee have recommended only one gun—the 9-pr. rifled bronze gun of 8 cwt.

13. Permit me to draw your attention to a very important bearing of this recommendation. It is the unity and simplicity of armament inherent to such a system, which will facilitate the supply of stores, and render that supply economical.

As to facility, take the battle-field. A battery of artillery obstinately engaged is running short of ammunition, or has a shaft or wheel broken. The first wagon met with, whether belonging to the horse or field artillery, will furnish exactly what is wanted. Or, to take a time of peace: two batteries relieve each other, one of horse, the other of field artillery; a subtraction of stores from the one, or an addition to the other, will complete the equipment. The neighbouring arsenal has only one species of stores for horse and field artillery; thus there can be no confusion, no mistake. I leave you to compare such a system with the S.B. field artillery with its four calibres!

Then think of the distances we have to deal with in India. As the crow flies it is about 1800 miles from Peshawur to Cape Comorin, and about 1300 to Calcutta; while from Cape Comorin to Kurachee is about 1400 miles. Now, if you will recollect that roads and rivers do not run as the crow flies, you may form some idea of the distances stores have to travel. I think, then, that in India of all countries, unity and simplicity of armament are most desirable, and we have both, on the proposed system, developed in a very high degree.

Unfortunately, however, I am obliged to confine these advantages to the horse artillery and *ordinary* field batteries.

14. There remains the want of ordnance for the attack of fortified villages, entrenchments, and the like. For this purpose I would have a 20-pr. howitzer and a 20-pr. mortar, both rifled. Neither of these pieces are yet in existence; but the S.B. 9-pr. can easily be converted for the one, and I see my way pretty clearly to the other with a weight of 2½ cwt. The latter piece, if it can be got to shoot well—and I believe this to be quite feasible—would likewise be invaluable towards the end of a siege.

I would arm a few batteries with the howitzers. They *must* move slowly, owing to the weight of the equipment; but they would not be wanted until a fight was well developed, and they would rarely change position. I would further arm a few garrison batteries with rifled field mortars at the opening of a campaign.

The remainder of the field batteries I would arm with the 9-pr. M.L.R. gun.

15. To the advocates of a 12-pr. I would commend the words I have quoted from the Prussian handbook.

Perhaps some of my hearers who may have been in the mutiny in India may object to me, that this 20-pr. howitzer will not replace the

8-inch mortar or howitzer of the Indian heavy field batteries. I do not pretend for one moment that it will; but it will handsomely replace the 24-pr. howitzers of the light field batteries: it will do more than this —I speak advisedly—it will be at least as efficient as the 18-pr. gun of the Indian heavy field batteries in opening a breach. It will thus compensate for the somewhat deficient common shell power of the 9-pr. M.L.R. batteries.

It will be recollected that no army goes a-field in India without a siege train of some sort. Let that siege train have the best and most powerful guns, howitzers, and mortars that you can give them, with a maximum weight in the largest gun of 50 cwt.—the weight of the 24-pr. siege gun. If you have a small fort to take, detach a portion of your siege train. But dragging about 18-pr. guns, 8-inch howitzers, and 8-inch mortars over a parade ground by elephants, drilling the battery as you would a field battery with all its minutiæ, appears to me to be an exhibition calculated to raise a smile.

Again, many would have a couple of howitzers with each field battery, for they say that just when you want your howitzers, they would be miles away. You would be in the position I once had the misfortune to be in, when we unlimbered our 6-pr. horse artillery smooth-bores against the stout stone-walled fort of Wudnee, at the opening of the Sutlej campaign. I am happy to be able to add that we judiciously refrained from firing, and that the fort was evacuated during the night, when we were all in bed.

16. But to return to the howitzers. There are, I think, insuperable difficulties in the way of mixing up the howitzers with the 9-pr. rifled guns. We all agree, I think, that we cannot have a really efficient common shell for field purposes much smaller than a 20-pr., with a bursting charge of about $1\frac{1}{3}$ lb. The piece must really be a howitzer, not a mortar on wheels, for it must do a little in the way of homicide as well as fire into or over parapets, at houses, &c. We must consequently have some segment and shrapnel shells. For these to be efficient, we must fire with a charge of at least from $\frac{1}{15}$th to $\frac{1}{10}$th of the weight of the shell. Such a charge behind a 20-pr. shell involves considerable weight in the piece—I think not much under 10 cwt.—as it is to fire at high angles, lest we smash our carriages to pieces.

But this is not all. You must recollect that this 20-pr. shell weighs more than two of your 9-pr. shells; and thus, if we associate the 20-pr. howitzer with the 9-pr., we can only carry with it less than half the number of rounds that we do with the latter. This would be a serious loss to suffer, and in a long campaign I think you would regret your reduced supply of ammunition. I think most of my hearers will allow that the association is unadvisable.

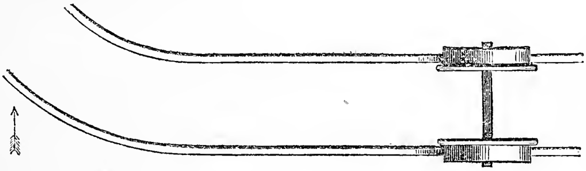
But has the reverse no advantages? Prussia, when armed with smooth-bores, had distinct howitzer batteries, and within my own service, I recollect all the 24-pr. howitzers in the army of the Sutlej being collected into one battery at Sobraon in 1845. I merely throw out the thought for your consideration.

17. I must now return to the 9-pr., and will say a few words about

its rifling and the fit of the projectile. You will recollect that I mentioned that the cast-iron of the projectile should not come in contact with the gun-metal of the bore. The depth of the groove of the Indian gun is $\frac{11}{100}$ths of an inch, and the projection of the studs is $\frac{13}{100}$ths; deducting one from the other, we have a clearance of $\frac{2}{100}$ths of an inch between cast-iron and bronze.* Up to about 2500 rounds fired from one gun tried by the Indian Committee, the impressions show that there has never been any contact between the hard and the soft metal. When, however, the grooves at the seat of the shell have been burnt out by the powder to such a depth that the top of the stud can no longer touch the bottom of the groove before the projectile is centred, then, of course, contact takes place between cast-iron and bronze, and the gun soon becomes unserviceable.†

Before a single round was fired, I convinced myself that what was clear in the afore-mentioned figures as to the isolation of the cast-iron from the bronze, was carried out in fact. A lamp was put into the bore, and then a shell. On looking into the bore, I saw a circle of light all round the shell, saving where it was interrupted by the studs. I knew then that all was clear. The drawing will give you some idea of the appearance.†

As to the centering. Supposing you are watching a railway train going away from you along a line of rails perfectly straight for a certain distance, and then curving away to the right. The most ordinary observation or thought would convince you that when the train comes to the curve, the flanges of the near or left wheels will rub against the inner edge of the rail they run on; thus the *near* rail will divert or drive the train to the *off* side.



Now, turning to guns, suppose you cut the breech off a rifled gun, so as to be able to look through the bore,‡ that the rifling has a right-handed twist, and that the lowest groove, as in the Indian gun, is immediately below the axis of the piece at the bottom of the bore; if you follow the course of this groove, you will see it ascend the left side of the bore, advance round over the top, and make its exit at the muzzle on the right side, after having made, in the Indian gun, two-thirds of a revolution. The groove, you observe, has been constantly turning in the same direction as the hands of a clock. Now, if we put a studded shell into the bore, the grooves will of course force the shell to revolve

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* Vide Figs. 1 and 2, where the shell is shown in section in the gun, excentric after being rammed home, and centred as it passes along the bore on its exit, the cast-iron of the shell being in neither case in contact with the gun-metal of the piece.

† Vide Fig. 2. ‡ Vide Fig. 3.

in the same direction. But if you could watch more closely, you would see that it is the side of the groove which is opposite to the direction of revolution which drives the stud round, just as the *left* rail, in the illustration I have taken, drives the train to the *right,* where the line of rails curves in that direction. We see, then, that one side of the groove does all the work in driving the shell round. Now, if that side were perpendicular to the bottom of the groove, it is true it would drive the shell round; but as the studs to enter the grooves must have some play—that is, the diameter over the studs must be less than the diameter over the grooves—there is no reason whatever why the shell should not be hard jammed towards one stud, the whole of the play being over the others. Instead, however, of the driving side being perpendicular to the bottom of the groove, if we make it oblique to the radius, and if we make the driven edge of the stud to conform to it, the rotation of the shell, or rather the force which causes it to rotate, will compel the studs to ascend the inclined planes of the driving sides of the grooves until the shell is firmly centred. If we could only centre the shell after loading and before firing—that is to say, bring all the driven sides of the studs against the inclined driving planes of the grooves, there would be much less damage done to the first foot or so of the grooves than actually takes place. For observe, on this system, when the shell is loaded, it is loose in the bore and grooves; but when the powder explodes behind it, the shell is sent forwards by a tremendous force impelling the studs against the driving sides of the grooves. This causes considerable wear for some short distance in front of the shell; but as there are some three or four feet of grooving uninjured in this way, the shooting is unimpaired for a great number of rounds.

In the Austrian system,* which is in principle precisely like that I have described, the whole of the groove is a curved inclined plane; and by way of locking them into a centrical position, the shells have warts or drifts at the nose which fit into a bayonet-joint on the sheet-iron flange of the rammer-head. As soon as the shell is set home on the powder, the loadsman turns the staff of the rammer to the right, and thus centres the projectile.

I am by no means satisfied that this centering before firing could not be managed with our muzzle-loading shells. But the endurance of the guns is already so great, that it seems hardly necessary to complicate the loading with even this trifling addition. The truth is that, thanks to the admirable workmanship in the Royal Arsenal, the shells are now made with a clearance between the sides of the studs and the grooves of only $\frac{1}{100}$th of an inch; thus the driven side of the stud must be brought in contact with the driving side of the groove almost instantaneously.

18. Let me now give you a few details of the bronze muzzle-loading field 9-pr. gun adopted for India.

The gun weighs about $8\frac{1}{8}$ cwt.† Its length of bore is 63·5 inches, its calibre 3″; its breech preponderance is about 8 lbs. The rifling is

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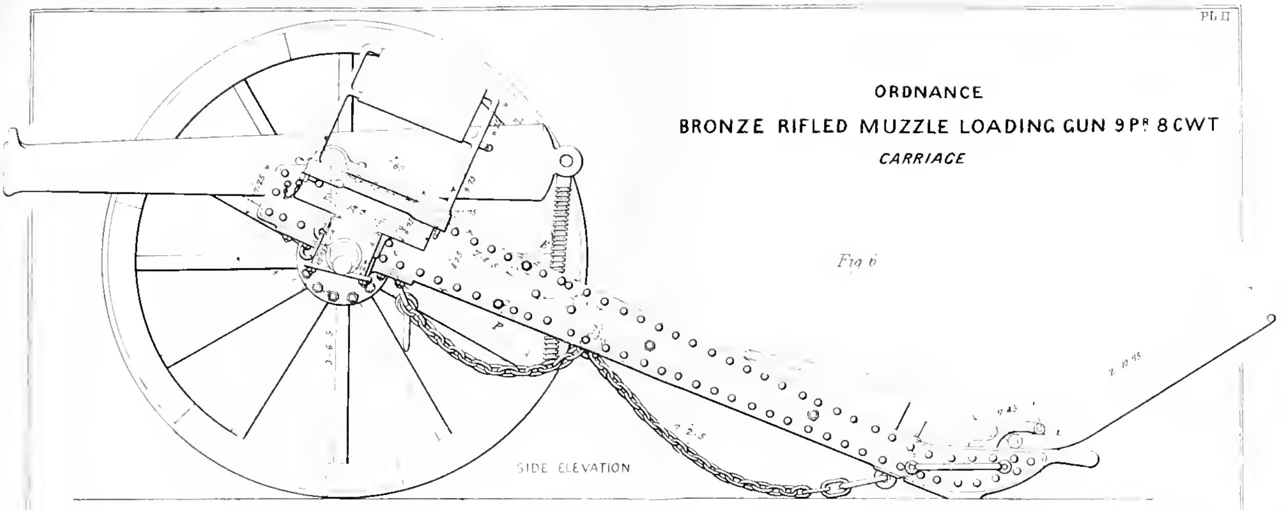
* Vide Fig. 4.

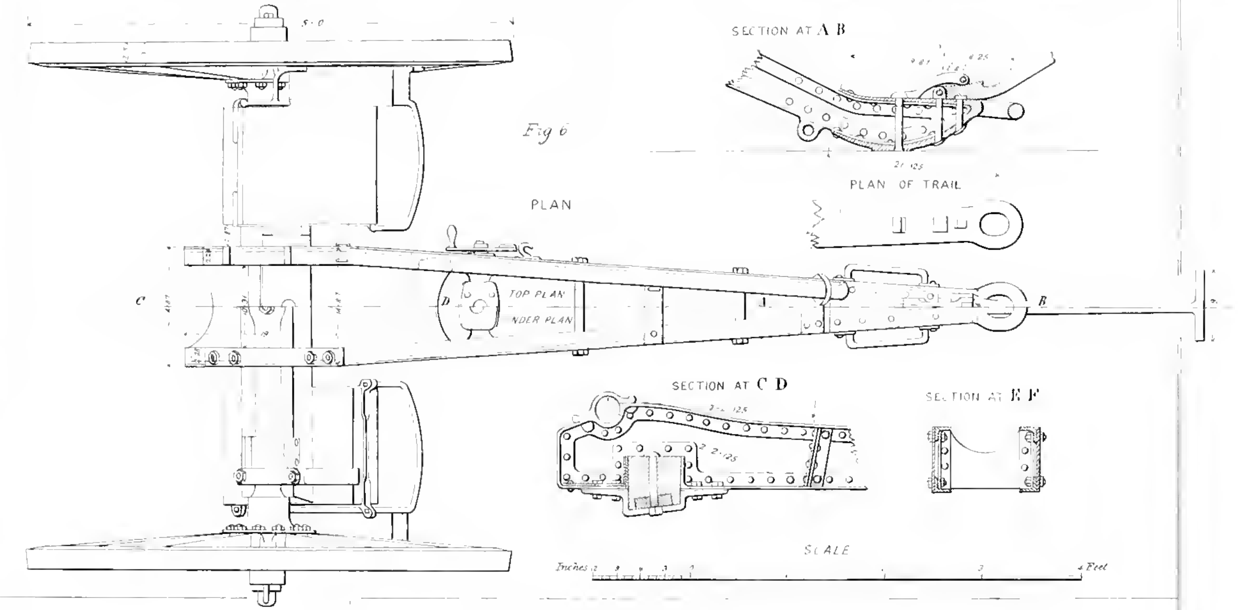
† Vide Fig. 5.

ORDNANCE

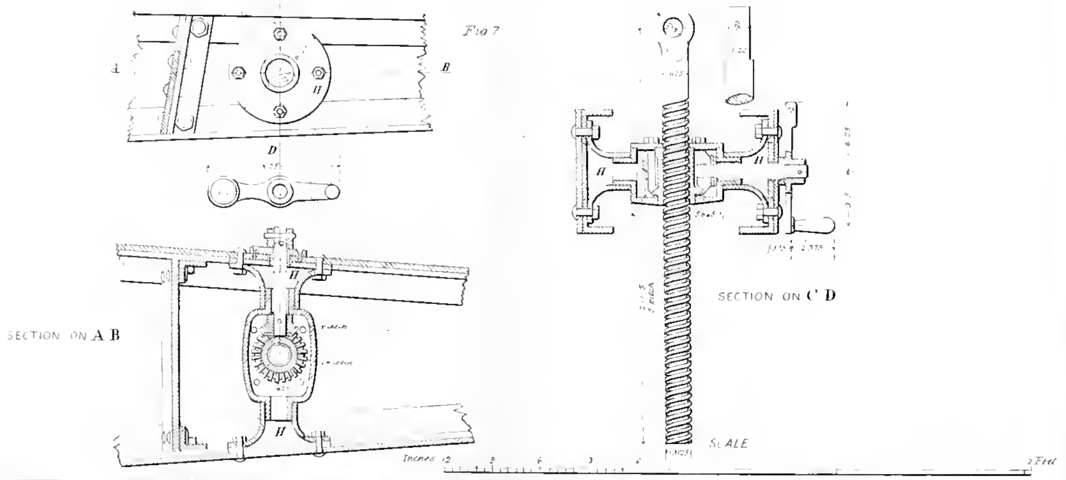
BRONZE RIFLED MUZZLE LOADING GUN 9 Pr 8 CWT

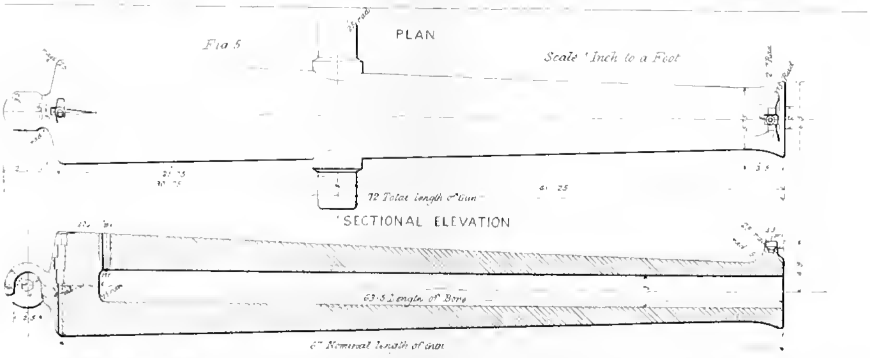
CARRIAGE





ELEVATING ARRANGEMENT





Lithographed at the Royal Artillery Institution

of the French form, slightly modified in size but not in principle; the oblique inclined plane forming the driving side of the groove is at 110° to the radius. The projectiles weigh 9 lbs. They are three in number. (1) Shrapnel, containing 63 bullets of 18 and 34 to the lb. (2) Common shell, containing 7½ oz. of powder. (3) Case shot, containing 113 one-ounce hardened lead bullets. A segment shell of the same weight is to form part of the equipment, as soon as a trustworthy concussion-fuze can be produced. This matter is left in such good hands, that there can be no doubt we shall shortly be in possession of a projectile for long ranges which can be fired as readily as case shot.

The charge of powder is 1 lb. 12 oz.; the nature of the powder being as yet undecided. The initial velocity with R.L.G. powder is 1381 feet per second, and with a special powder made at Waltham Abbey, it is within one or two feet of 1400 feet per second.

The accuracy and uniformity of shooting of this gun is, I think, remarkable. This short table will give you a fair notion of it:—

Elevation.	Mean range.	Mean difference of range.	Mean reduced deflection.
degs.	yds.	yds.	yds.
2	1176	14·2	0·5
3	1552	17·1	0·9
7	2665	18·9	0·8

This means that at 3° of elevation, if you were to fire 100 rounds, 50 shells would be found to have fallen 17 yards short of or beyond the mean range of 1552 yards, and $\frac{9}{10}$ths of a yard in width right or left of the line of fire.*

As to rapidity of firing, 50 rounds have been fired in 7 minutes; and as to rapidity combined with accuracy, 50 rounds were fired in 13 minutes, making 27 hits in a 9 feet target at 1000 yards. Further, 140 rounds were fired from one gun without stopping, at the rate of 3 rounds a minute—that is, continually for three-quarters of an hour. The metal became so hot as to boil water.

The shrapnel shell, fired at a column of troops, represented by targets 54 feet wide by 9 feet high, in four ranks 20 yards apart, made 48 hits *through* 2″ boards at 1200 yards, 40 through at 1600 yards, and 10 through at 2000 yards. The case shot, fired at two rows of the same targets, 50 yards apart, at 300 yards, gave 6·5 hits through 2″ boards; 11·9 lodged, and 3·3 struck, in total 21·7 hits per round.†

The sighting of the gun is central, and both muzzle and breech-sights are completely protected against injury. The plate carrying the notch in the breech-sight is capable of lateral deflection. This refinement

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* This interpretation is not mathematically accurate, but quite near enough for all practical purposes.

† An improved pattern case shot, fired on 20th May, 1870, gave 42·5 hits through 2″ boards, 13·3 lodged, 15·2 struck, in total 71 hits per round.

will scarcely be necessary in firing at troops; but it may be required in certain cases where great accuracy is desirable—such as firing at a single gun, at the pillars of a house, or the voussoirs of an arch, &c. The tangent scale is set in at an angle of 1° 30′ to the left of the vertical, to correct the deflection or drift up to 1500 yards due to the pitch of rifling and velocity.

The venting is that of the smooth-bore guns, excepting that the vent is vertical, striking the axis of the piece at 0·6″ from the bottom of the bore. The object of a return to the old venting, is to ensure the whole of the cartridge bag being blown out at each discharge. The Indian Committee tried several patterns of sponges calculated to fetch out *débris* of cartridge; but this venting left them nothing to do in this respect.

19. The gun-carriage is chiefly of iron;* the trail is composed of two plate-iron brackets, stiffened with angle-iron, connected by through bolts, and ending in the trail-eye. The axle-arm is not steeled so as to be suited to the gun-metal pipe-box of the nave.

The wheels are of the Madras pattern, so well known as not to need description.

The fittings of the ammunition boxes are of the simplest nature, and are so contrived that when the lid is closed, each shell is held fast in its place by wooden compressors in contact with the lid.

Right and left of the gun are two boxes, the lids of which can be made available as seats for two gunners with the *field* batteries, while two are carried on the limber, and two more on the off horses of the team; so that the gun can go into action independently of its wagon, with its gunners fresh for their work.

In the near box are three case shot and three charges, with priming irons and tube-pouch. In the off box it is proposed to place a range-finder and one round of case shot. The limber contains 30 rounds, but accommodation is provided for 36.

The weight dragged by the gun-team, with men dismounted, will be about 33½ cwt.; that is, 1½ cwt. heavier than the Royal Horse Artillery 9-pr. breech-loader, and about the same weight as the 6-pr. smooth-bore of Royal Horse Artillery in India.

The wagon and limber contain 96 rounds, or 128 filled up, the latter being interchangeable at will with the gun-limber. The weight behind the team is about the same as with the gun, 33 cwt.

The forge wagon differs little from that formerly in the service, with the exception that iron is brought into use as much as possible.

With regard to the endurance of the carriages in firing, one has had fired from it some 4000 rounds. For 500 rounds, the wheels were lashed to posts to stop the recoil. The carriage at this moment appears to be as good as when new.

The gun-carriage has met with the highest approbation of all who have used it, and I believe all who have seen it. It was designed in the Royal Carriage Department, at Woolwich, and appears to me to reflect the greatest credit on its designer.

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* Vide Fig. 6.

The adoption of this carriage for India, relieves us from a very great difficulty. We have magnificent wood in that country, but it is getting scarce, the scarcity being due to the introduction of railways, and to the forests having been neglected. The timber for the manufacture of the carriages had to be stacked in covered sheds for several years before use. Of the timber thus stored, a great deal split in drying to such an extent as to be useless for the larger portions of the carriage, viz. the trail-beam and naves. Thus, when a stress came, as in and after the mutiny, the main difficulty in equipping the batteries with their carriages was the want of seasoned wood.

With the new carriage, the largest piece of wood required is for the axle-bed, which acts as a mere cushion: its soundness is not vital to the efficiency of the carriage. The spokes, felloes, and the slight woodwork of the limber will not be, under almost any circumstances, difficult to supply in India; for it is easy to get a small piece of sound wood, when it might be impossible to find a large piece of the same quality.

Again, the open trail of the iron carriage permits of the passage of Sir Joseph Whitworth's* admirable elevating-screw. With the wooden carriage, you were compelled to bore an oval hole of very considerable size through your beam, at the very point where it was weakest. Around this lamentable hole, you bored four smaller holes for the holding-down-bolts of the socket of the ball-nut of the elevating-screw. This defect of construction is avoided in the bracket-trail.

Once more, we are subject to the most dreadful pest of white ants in India, against which there is only one effective precaution: it is to move all articles made of wood every day. With an equipped battery this amounts to mere inconvenience—you have to look after your wagons in your sheds; but in arsenals and manufactories, the difficulty is a very serious one. In our new carriages, iron being largely used, those who have charge of stores will have all the less to fear.

20. Let me now succinctly compare this muzzle-loading 9-pr. with the breech-loaders of the service.

I have no doubt in the world, that a gun on the Armstrong breech-loading system, firing 9-pr. shells with a charge of $1\frac{3}{4}$ lb., and weighing 8 cwt., could be made, which would equal the 9-pr. muzzle-loader bronze gun in accuracy, and in flatness of trajectory; but there can be no manner of doubt that the breech-loaders of the service are on both points inferior to it.

The adoption of the latter system entails the following heavy list of complications:—

(1) Detonators to the fuzes, which are liable to injury by climate or jolting, despite elaborate packing arrangements.
(2) Breech-screw, with tappet lever and keep pins with reserve.
(3) Vent-pieces with reserve.
(4) Facing implements.

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* Vide Fig. 7.

(5) Armourers' and special tools.
(6) Lubricators and tin cups.
(7) Lead-coating to shells involving India-rubber discs in the boxes.
(8) Browning and greasing the gun.

These complications may or may not form serious objections to the breech-loading gun in Europe; but for India, in my opinion, there is no doubt in the matter. There we have an atmosphere which in a short space of time alternates between that of a heated oven and a steam-bath. Expansion, contraction, rust, mildew, and so forth, try war stores by tests ten-fold as severe as any they are subject to in Europe. Again, the source of supply is so distant—if we were to rely on England, as perforce we must with the breech-loading system—that the country might well be lost before fresh supplies could reach us, even supposing them unintercepted on the high seas. On the other hand, large stores might be laid in, in fortified arsenals, so as to meet all possible wants.

Independent of the consideration of the effect of the climate on such stores, the recollection of Delhi in 1857 reminds us that we might again be putting arms into the hands of our domestic enemies for our discomfiture—as the first process in every rebellion or revolution is to seize a depôt of arms. A country is thus all the safer, the fewer arms she has in dangerous districts beyond her own immediate wants.

Manufacture in the country is, then, the best security. I shall probably be told that for a campaign you must trust to your stock in hand and not to manufactories. I reply that a campaign such as we had in India during the mutiny, would denude most of your arsenals, and that while the troops are fighting in the field, your manufactories, working night and day, should, if properly organized, be able to supply the arsenals nearly, if not quite, as fast as they issue stores. Thus, instead of being exhausted at the end of a campaign, you would be nearly as strong as ever in *matériél.*

On the other hand, what advantages does the breech-loading system hold out to us in India? I confess that the only one that I can see is assimilation with the Royal Artillery at home; and this advantage I humbly hope and trust we shall soon have by the universal adoption of the muzzle-loading system.

21. Let me now give you in two words a *per contra* list of the advantages of that system:—

(1) Simplicity throughout the equipment, involving the possibility of manufacture in India.
(2) Stores little liable to injury from the climate of that country.
(3) Economy.

These are the main advantages, though there are many others of a minor and less general nature.

22. Before concluding, I do not think it out of place, now that we have got a gun for India, to direct your attention to the question of

keeping it. Let me give you an idea of how guns are taken in action in these days of breech-loading small-arms.

> "At Lipa, near Sadowa, ten Austrian guns fell into the hands of the Prussians, their teams having been shot down from a distance almost entirely by a section of the Fusileers of the Guards.
>
> "Out of the 113 pieces taken from the Austrians in actual fight, 108 were taken by infantry, and almost all by swarms of skirmishers. The method of attack was always the same. The skirmishers got under cover within range of their rifles, and thus knocked over men and horses; they then charged the battery, generally speaking abandoned by its infantry escort, and with three-fourths of its horses down, the battery fell an easy prey."

Now, this Austrian artillery behaved heroically; it fired case shot to the last, and covered the retreat of the army.

That is to be our field artilleryman's fate, unless we are better backed than were the gallant Austrian gunners!

But how is this backing to be managed?

The fire of modern small-arms is deadly at 500 yards; at 800 it is formidable; and even at 1200 yards, with the Martini-Henry, it is something serious.

A flat trajectory will avail you much; but if your opponents of the infantry are under cover, even at these short distances your guns will do so little that the expenditure of ammunition would not be justifiable.

What is to be done, then, with these skirmishers?

Every battery when engaged should have a permanent escort—not only theoretically, as at present, but practically—and that escort must on no pretence whatsover abandon its charge, as was the case with the Austrians.

If the enemy's skirmishers advance against a battery, they must be met by skirmishers, especially on their flanks. If men and horses are being shot down by light infantry, one of two things must be done: the battery must retreat at once, or the escort, strengthened if necessary, must drive back the skirmishers.

Thus far I am clear; but suppose the battery has to advance 1000 yards at a trot and gallop, where would be your infantry escort?

I see nothing for it but to detail a cavalry escort to cover the advance in extended order, and to retire by the flank as soon as the battery has got into action, the cavalry being relieved by the infantry escort. This is complicated, but something of the sort appears inevitable.

It would seem that now, more than ever, a battery in action must be dry-nursed; that the General under whose orders it acts, should be impressed with the indubitable fact that a battery of field artillery is, like gold, a very valuable possession; and that in proportion to its value, it is all the more likely to be robbed from him, unless he guards it with all the care that he bestows on his purse.

In my own experience of service, escorts to batteries were often told off, but they invariably were left behind on the advance of the battery, and rarely came up to it again, being ordered off elsewhere and otherwise employed. This must no longer be permitted, on pain of the loss of our guns.

23. In conclusion, casting a glance back at our smooth-bore field artillery, and to its advantages in ricochet, I cannot regret it in any respect but one—viz. its more powerful case shot fire. In all other respects, the rifled gun has the advantage. When the smooth-bore round shot hit an object 100 feet long by 6 feet high once in every four rounds at 1000 yards, one-half of which was by ricochet, the Indian gun would hit *at least* three times out of four rounds. It is very well to say the round shot will go bowling on, and hit half-a-dozen objects before it comes to rest. I ask, is it better to hit the object aimed at three times out of four, than to miss it as many times, and to trust to chance that something else may be in its way before its course is finished?

I have thus given you some idea of the field gun for India, and in taking leave of the subject, venture to express before you my fullest confidence in the system which has been adopted. As far as my lights go, the gun compares favourably with any existing field gun—its endurance ample, its uniformity of range and accuracy of direction admirable, its simplicity great, and its trajectory the flattest that has come to my cognizance. The bronze gun and its iron carriage are suited to India, and their manufacture to the artificers we have at our disposal. They have, however, two great tests to undergo, more severe than any they have been put to at Shoeburyness, viz. time and actual employment on the battle-field. I have no doubt of their successfully enduring both those tests.

I beg to thank you for the attention you have been good enough to pay to my feeble exposition of "The Field Gun for India."

At the conclusion of the reading—

Major-General F. M. Eardley-Wilmot invited discussion on the subject of the paper, and called upon—

Colonel Adye, R.A., who said:—I had intended offering some few remarks upon this subject, but Colonel Maxwell has entered so fully into the question that there is very little left for me to say; and if there were more, I feel I should say it less ably than he. We are all very much indebted to him for the admirable lecture he has given—(applause)—and I, who have been connected with him on the Committee for some time past, can testify to his thorough knowledge of the subject on which he has treated. If you will allow me, I should like to say a few words, not so much as to the advantage of the muzzle-loading gun for India, but as to the present condition of our field artillery generally. That the breech-loader is an admirable gun in many respects, I do not doubt; and, further, it was introduced at an opportune time, when all Europe was looking anxiously for rifled guns. At the same time, I am bound to say that, in my opinion, its defects made themselves apparent almost as soon as it was introduced. It was found to be complicated and delicate; and not only delicate, but liable to get out of order at a critical time—that is, when the enemy is coming on. (Laughter.) In China, in New Zealand, and in the naval actions in Japan, it was found that the breech-loading gun was apt to go wrong when it was most wanted to go right. And besides its delicacy and liability to get out of order, the breech-loader was found inconvenient, because it required the employment of special artificers and special tools to keep it in repair. Its projectiles, again, have not fulfilled the expectations that we had been led to form of them, and its fuzes have proved the source of endless anxiety, trouble, expense, and change. Instead of one projectile, as originally proposed, we have got back to common shell, common case, and shrapnel. There are two serious defects in the fuzes; the first is, that when rattled about in the ammunition-boxes, they are liable to go off by themselves, which, to say the least, is uncomfortable —(laughter)—and the second is, that when kept for any time they deteriorate, either from climate or from chemical action, and consequently do not go off at all. (Laughter.) The Armstrong and Whitworth Committee of 1864 went fully into this question, and they reported strongly in favour of muzzle-loading guns. The subject was then considered by the Ordnance Select Committee, Colonel Maxwell in India, and the Royal Navy pressing for muzzle-loaders; and it was therefore again referred to a Committee, of which General Sir R. Dacres was president, and of which I was one of the junior members. This was in 1866, and our unanimous decision was that no more breech-loaders should be made. Then again, in 1868, it was resolved to adopt muzzle-loaders for India; and even last year, the Dartmoor Committee—of which General Dickson was president—made a report recommending the introduction of muzzle-loading howitzers, and the withdrawal of the present defective fuzes. For years past we have been thus drifting towards muzzle-loaders, and after giving the fullest attention to the subject, I unhesitatingly say that I have the greatest confidence in the gun which Colonel Maxwell has made the subject of his lecture. In range, accuracy, and power it is superior to the breech-loading field guns of the service, and it is cheaper. The gun and its ammunition are simple in character, and neither are likely to get out of order; and therefore I consider them as well adapted for the rough purposes of war. (Applause.)

Major-General F. M. Eardley-Wilmot said:—As it does not appear—which I greatly regret—that there is any desire to prolong the discussion, the duty devolves upon me of proposing a vote of thanks to Colonel Maxwell for the admirable paper which he has prepared. (Applause.) Doubtless there are many present who have long waited to see something like a settlement of this question, having always advocated the use of muzzle-loading guns for field service, for the reasons set forth by Colonel Maxwell. To such it must be a great source of satisfaction to find that these reasons have at last had their due effect. (Applause.) Remarks have been made on the delay which has taken place in making our report; but when you consider that we had to prepare and agree upon, not only a gun and a carriage of new material, but on a complete field equipment, including all questions connected with dimensions, weight, and serviceable efficiency, a year, or even two, could not be considered as very long. It is easy enough hastily to adopt a system, but we considered it to be our duty to try and prevent, as much as possible, the too hasty adoption of any portion of the equipment. I may say, as regards the expense, that very many experiments had to be made, not only to test the endurance of the bronze gun, its range and accuracy, but also in connection with the charge and projectiles. These necessarily occupy time and cost money. The whole expense, however, will not exceed £3000. (Applause.)

Colonel WRAY.—Including the cost of all the materials?

Major-General EARDLEY-WILMOT.—Yes; and perhaps we may diminish the cost, if the Government are induced to be so liberal as to purchase the guns, now unfit for issue, which have been fired for endurance. When you consider that the Armstrong and Whitworth trials alone cost near about £30,000, it will be admitted that we have been duly careful on this point. (Applause.) As president of the Committee, I feel that I cannot say anything on the question of our proposals; but I cannot lose the opportunity of stating how much the Committee is indebted to Colonels Maxwell and Wray for the labour, anxiety, and trouble they have had in bringing the work to so successful a termination. Colonel Maxwell has been indefatigable in devising and preparing arrangements in connection with the gun and all parts of the equipment, and, in connection with Colonel Wray, has personally watched over their manufacture. I need hardly say how cordially, therefore, I return the thanks of this meeting to Colonel Maxwell for his admirable paper. (Applause).

APPENDIX.

TABLE OF THE PRINCIPAL DIMENSIONS AND WEIGHTS OF VARIOUS HORSE ARTILLERY GUNS AND THEIR EQUIPMENT.

	Breech-loaders.		Muzzle-loaders.		Breech-loader.	Muzzle-loader.
	Prussian.	English.	Austrian.	French.	Russian.	Indian.
	4-pr.	9-pr.	4-pr.	4-pr.	4-pr.	9-pr.
THE GUN.						
Calibre ....in.	3·089	3	3·17	3·41	3·42	3
Number of grooves	12	38	6	6	12	3
Depth 〃 ....in.	0·051	0·045	0·175	0·113	0·051	0·11
Width 〃 ....in.	in front 0·6 in rear 0·71	0·148	1·54	0·67	0·61 0·77	0·8
Length of bore rifled ....in.	59·6	...	42·2	49·4	47	63·5
Pitch-angle ....degrees	3° 45′	4° 43′	8° 30′	6° 53′	4° 35′	5° 59′
Length of bore ....calibres	22·5	17·5	15	16	17	21·2
Weight of piece ....cwt.	5·413	6·5	5·177	6·5	6·43	8·1
AMMUNITION.						
Diameter of common shell ....in.	3·089 3·192	3·02 3·07	3·089	3·305	3·418 3·522	2·94
Length of nose of do .... 〃	1·86	...	3·19	2·83	2·08	3·13
Length of cylinder of do .... 〃	4·47	...	3·91	3·47	4·83	4·8
Total length of do .... 〃	6·33	...	7·1	6·3	6·91	7·93
Weight of common shell filled ...lbs.	8·96	8·5	7·99	8·9	12·5	9
Weight of common shell bursting charge ....oz.	5·9	5	7	7	7·9	7·5
Number of balls in shrapnel	...	42	80	85	...	63
Weight of shrapnel ....lbs.	...	9	8·03	9·72	...	9·25
Number of balls in case shot	48	...	56	41	40	108
Weight of case shot ....lbs.	6·59	...	7·94	9·73	8·43	9
Service charge of powder .... 〃	1·1	1·125	1·1	1·21	1·35	1·75
Ratio of weight of charge to shell ...	$\frac{1}{8{\cdot}1}$	$\frac{1}{8}$	$\frac{1}{7{\cdot}3}$	$\frac{1}{7{\cdot}4}$	$\frac{1}{9{\cdot}3}$	$\frac{1}{5{\cdot}1}$
Initial velocity ....ft. per sec.	1184	1058	1093	1066	?	1381
GUN CARRIAGE.						
Track ....in.	60·24	62	59·7	56·3	58	62
Diameter of wheel .... 〃	61	60	52·5	56·29	48	60
Weight of gun-carriage, equipped, but without gun ....cwt.	9·35	10·5	8·6	8·42	8·39	10·5
Weight of gun-carriage, equipped, but with gun ....cwt.	14·04	17	13·78	13·88	14·07	18·75
Rounds carried on gun	1	...	3	4	...	4
LIMBER.						
Diameter of wheel ....in.	48·6	60	43·2	56·3	48	60
Weight of limber, packed ....cwt.	15·75	15	9·86	10·1	8·95	14 14·6
Number of rounds in limber	48	34	36	40	18	30 36
Proportion of ammunition in limber: common shell	40	6	20	32	8	8
carcass	4	...	...	...	...	...
shrapnel	...	...	10	5	6	16
segment	...	18	...	...	...	...
case shot	4	10	6	3	4	6
MISCELLANEOUS.						
Weight of gun behind team ...cwt.	30·5	31·5	23·63	25·76	24·4	33·5 34·1
Number of horses in team	6	6	4	4	4	6
Weight for each horse in draft, men dismounted ....cwt.	5·1	5·2	5·9	6·4	6·1	5·7
Number of rounds per gun, limber, and one wagon	157	124	156	156	130	124 148
Number of men carried on limber.	2	2	1	...	2	2
Number of men carried on gun ...	3	...	3	3	3	...

N.B.—The numbers bracketed in the column referring to the Indian gun, are to be taken according to whether each ammunition box contains 15 rounds only, or is filled up with 18.

A DESCRIPTION

OF

THE "SCALE OF SHADE,"

FOR REPRESENTING GROUND IN RELIEF, NOW IN USE AT THE STAFF COLLEGE, R.M. ACADEMY, AND SANDHURST COLLEGE.

BY

CAPTAIN G. A. CRAWFORD, R.A.

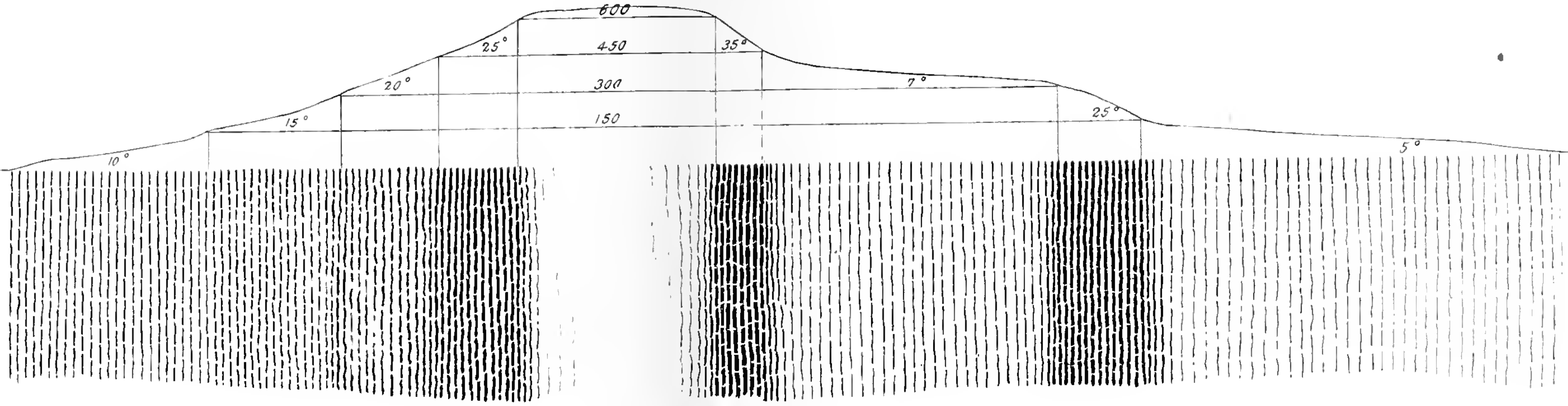
INSTRUCTOR IN SURVEYING, R.M. ACADEMY.

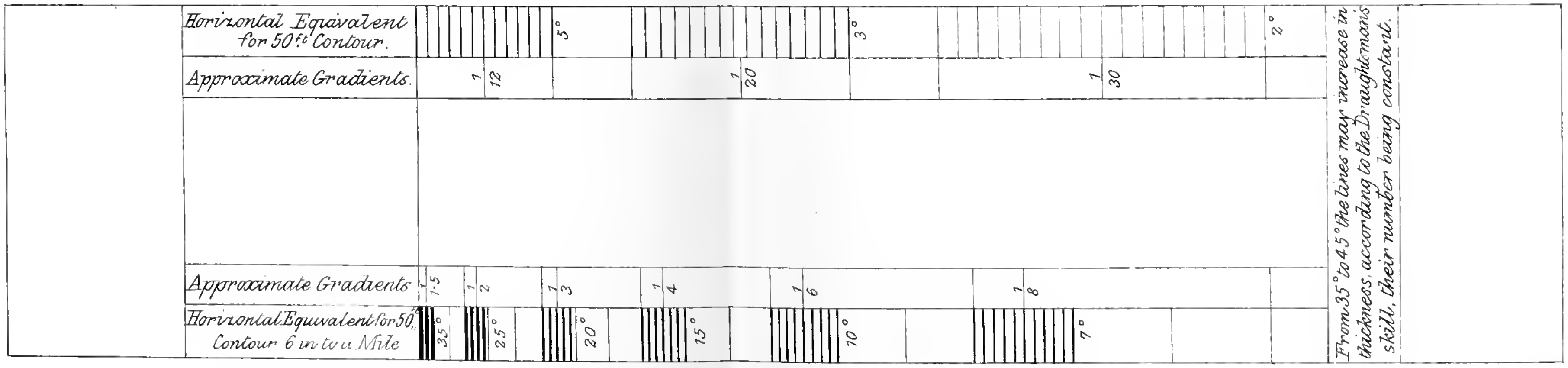
In representing the inclinations of ground by shade, supposing the light to fall in vertical rays, a plane surface of a given area—say a piece of paper a foot square—would receive the greatest possible number of rays on its surface when held truly horizontal; and the nearer the paper is inclined to the vertical plane, the fewer will be the number of rays falling upon it. On this principle, topographers have adopted the plan of depicting the greatest inclination by the darkest shade, reducing the amount of shade as the incline approaches the horizontal, which is represented by "high light." Major Lehman, of the Saxon army, some years ago, endeavoured to reduce this system to a certain amount of mathematical accuracy, by assigning to different shades definite values in degrees, and so obtaining what has been termed a "scale of shade." Attempts have been made to introduce a scale of shade into this country, but without any result until, within the last two or three years, Lieut.-Colonel Scott, R.E., suggested the use of such a scale as likely to produce a certain amount of uniformity in the work of different draughtsmen, and Captain Webber, R.E., and others, wrote pamphlets upon the subject. At one of the meetings held in London by the Royal Engineer Officers, to which the instructors in surveying and topography at the different military colleges were invited, the matter was fully discussed, and the scale of shade I am now about to describe decided upon by the Council of Military Education, and its use authorised by H.R.H. the Commander-in-Chief.

It will be observed that 35° is the steepest inclination represented by shade upon the scale. Slopes of 45° can be shewn by as dark a shade as the draughtsman's pen will permit of; inclines above 45° are supposed to be

SECTION OF A HILL REPRESENTED IN PLAN BY SHADE ACCORDING TO THE SCALE.

$\frac{1}{10560}$





From 35° to 45° the lines may increase in thickness, according to the Draughtsman's skill, their number being constant.

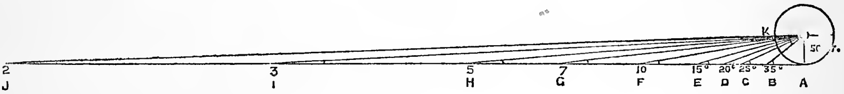
Lithographed at the Royal Artillery Institution

too steep for manœuvring troops over, and may be depicted as impracticable ground. By giving the maximum amount of shade to the 45° incline instead of 90°, we shall have increased our powers of discrimination between that incline and the horizontal plane.

The scale of shade is arranged to enable the draughtsman to shade the different slopes, on the horizontal hachure system, the hachures being drawn in directions coincident with the contours of a hill. Its use entails the necessity for contours to be run at certain vertical intervals, dependent upon the scale to which the plan is drawn. It is adapted to a scale of 6 inches to the mile, the vertical interval of the contours being 50 feet; but can also be used when the plan is drawn on any other scale—such as 1, 2, 3, 9, 12, 18, 24, &c. inches to the mile—as long as the vertical interval of the contours is altered accordingly.

If we refer to Fig. 1 (which is drawn to nearly three times the original size of the scale of shade), it will be seen that the shaded spaces marked 35°, 25°, &c. are each equal to the distance apart of the contours in plan, where the vertical interval is 50 feet and the drawing on a scale of 6 inches to the mile. Let *O* be taken as centre, and *OA* (= 50 feet vertical interval of contours), as radius, a circle described, and angles of 35°, 25°, 20°, 15°, 10°, 7°, 5°, 3°, 2°, be laid off in the quadrant *AOK*, we shall have *AB, AC, AD,* &c., the co-tangents of these different angles of inclination to radius *AO,* and will be the distances apart in plan of contours, having a vertical interval of 50 feet; so that, if in possession of a plan drawn on a scale of 6 inches to the mile, and the contours run at vertical intervals of 50 feet, by means of the scale of shade the value of the different inclinations in degrees can be ascertained. Thus, if on applying the scale of shade (see Plate) to the plan, it is found that the interval between two adjacent contours is equal to the fifth shaded space on the scale of shade, the inclination at that spot will be 10°.

Fig. 1.

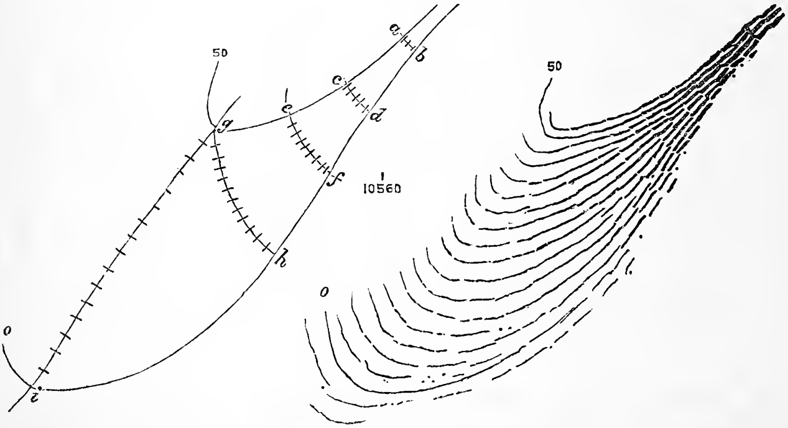


These spaces, *AB, AC, AD,* &c. are then filled in with hachures, or strokes—these strokes being drawn thickest and closest together so as to give the greatest amount of shade for the slope of 35°, and becoming gradually finer and further apart as the incline approaches the 2°, the least inclination—and a gradation or scale of shade thus obtained. The number of hachures assigned to each inclination is purely arbitrary; the number adopted is supposed to distribute the light and shade in as even a progression as possible.

It will be observed, beneath these shaded portions two vacant spaces exist; these spaces are each equal to the cotangent (to radius *AO*), for the different angles marked on them; from the top, therefore, of one shade to the top of the next shade below, we shall have the distance apart in plan, or horizontal equivalent for three contours of 50 feet, given on the left hand side of the scale, but the horizontal equivalents for one contour only on the opposite side—viz. for 5°, 3°, and 2°. The inner column on the scale gives the approximate gradients or numerical value of the base in terms of the perpendicular for each incline.

The scale of shade, printed on paper, is pasted on the flat side of a box-wood protractor,* so that the bevelled edge can be applied to any position of the plan, and the inclination—and hence the number, thickness, and distance apart of the hachures to depict that inclination—ascertained. A few lines—as *ab*, *cd*, *ef*, &c. (Fig. 2)—may be drawn in pencil at right angles to the contours, or in the direction water would take to trickle down the hill. These lines, termed guiding lines, will be of great assistance as regards the directions of the hachures; as each hachure, when passing over a watercourse, watershed, or guiding line, should be drawn at right angles to it.

Fig. 2.



In Fig. 2, if the scale of shade be applied to the guiding line at *ab*, the inclination at that spot will be found to be 35°, as the line *ab* coincides with the horizontal equivalent for 35° on the scale. In like manner, the inclinations at *cd*, *ef*, *gi*, and *gh* can be found, and the number of hachures, and their distance apart, marked off in pencil along each of these guiding lines, the scale of shade being kept opposite the draughtsman to guide him in copying the thickness of the hachures. After a little practice, the draughtsman will get so accustomed to the handwriting, so to speak, resulting from copying carefully the scale of shade at first, that he can trust almost entirely to memory, and obtain a tolerably accurate representation of the ground.

It has been shewn that the scale of shade is adapted to the 6 inches to

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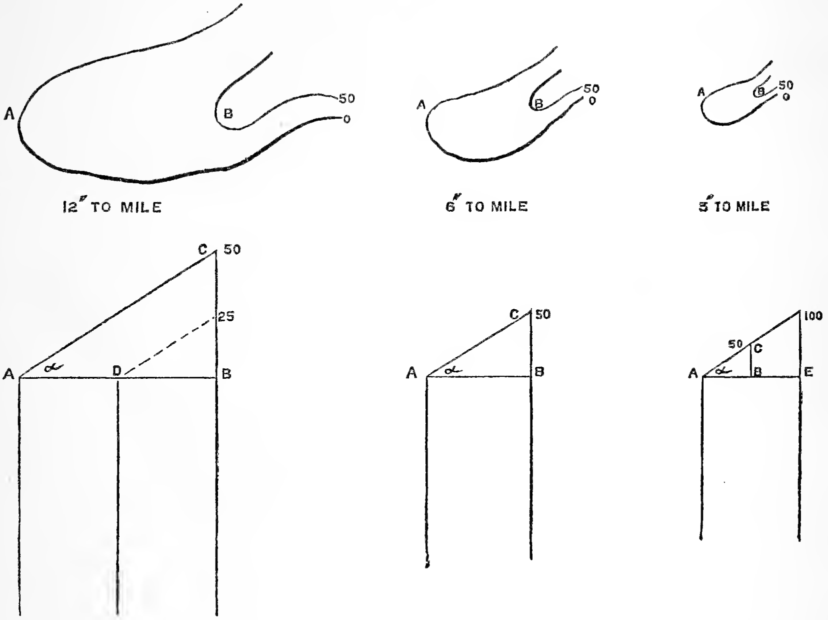
* Can be bought at Elliott's, Strand; or Boddy's, Woolwich, price 1s. 9d.

the mile scale; if we refer to Fig. 3, it will be seen that it can be used for

Fig. 3.



any scale which is either a measure or a multiple of the 6 inch scale, by simply altering the vertical interval of the contours, and thus obtaining horizontal equivalents corresponding to those marked on the scale of shade. In Fig. 3 we have three representations of the same slope (in section), on three different scales—viz. 12, 6, and 3 inches to the mile—*BC* the vertical interval between the contours (= 50 feet), α the angle of inclination, and *AB* the distance apart of the contours in plan. Now, if the scale of shade was applied along the guiding line *AB* between the contours in each instance, we should have the inclination α represented—

In the 6 inch plan by the true amount of shade,
" 12 " the shading would be too light,
" 3 " " " dark.

In the 12 inch representation, the base *AB* is double the base in the 6 inch plan; in order, therefore, truly to depict the angle α, it would be necessary to bisect *AB* in *D*, and apply the scale of shade between *A* and *D*, and again between *D* and *B*. If the plan, therefore, is on a scale of 12 inches to the mile, the contours should be run at vertical intervals of 25 feet; we shall thus have horizontal equivalents corresponding with those marked off on the scale of shade, and consequently the different inclinations represented by the amount of shade assigned to them. In the 3 inch representation, the base or distance apart of contours in plan is evidently half that of the

6 inch plan. In order truly to depict the incline *a* in this case, the contours should be run at a vertical interval of 100 feet, and we shall thus obtain a horizontal equivalent equal to the base *AB* on the 6 inch scale—viz. *AE* in the figure.

By a simple proportion, the vertical interval at which the contours should be run can easily be ascertained. For example, supposing we are making a military sketch on a scale of 30 inches to the mile, we should have—

$$\begin{array}{ccccc} \text{in.} & & \text{in.} & & \text{ft.} \\ 30 & : & 6 & :: & 50 \\ & & & = & 10 \text{ ft. vertical interval;} \end{array}$$

the scale of shade can then be applied to the plan of these 10 feet contours.

When the sketcher is in possession of a plan on the 6 inches to the mile scale, and contours with a vertical interval of 100 feet given, and is desirous of shading the plan, it will be necessary to interpolate a contour half way between those given; the scale of shade can then be applied, and the inclines will then be shaded in accordance with it. If, on the other hand, the plan shewed contours with a vertical interval of 25 feet, it would be necessary to apply the scale of shade between every second contour. Again, if the scale of the plan was other than 6 inches to the mile (say 30 inches), and the contours given were of a vertical interval of 20 feet, it would be necessary to interpolate a contour in this case before applying the scale of shade, as the vertical interval for a scale of 30 inches to the mile should be 10 feet.

The opinions as regards the advantage of using a scale of shade, appear to be very various; some are strongly in favour of it, and others, on the other hand, are very much averse to it. I believe it is of great use for *instructional purposes;* for it convinces a draughtsman that, by means of his pen or pencil, he can obtain at least nine different shades—whereas a draughtsman who has not practised with it is apt to restrict himself to two or three, and consequently represents only two or three inclinations of ground. But when a good draughtsman has done five or six careful drawings with it, and thus learnt the *handwriting,* he can afford to trust to memory for shading his drawing, and only use the scale of shade to check his work occasionally; for he will find by adhering *strictly* to the rules laid down for its use, they will rather cramp him than otherwise—whereas a bad draughtsman, to obtain anything like accuracy, will have to go through the laborious process of using it mathematically. The latter may be compared to a man who, having to cross a number of wet ditches, and knowing he cannot jump them, sees the advisability of carrying a plank with him to act as a bridge; the former, having to cross the same ditches, and knowing he can jump them, will find the process of carrying a plank with him rather an impediment than otherwise.

The fact of getting a number of draughtsmen to shade an inclination by the same amount of shade, is certainly a great advantage; for eight or ten men's work can be put together, and form a tolerably harmonious whole.

The handwriting of the scale of shade is, perhaps, rather too course; for when a shade has to be made up of a number of strokes, if these strokes are placed beyond a certain distance apart, the eye will begin to count units, and consequently lose the idea of shade.

A few remarks on Hill Sketching.

By the aid of a pocket compass and a scale of shade protractor, a tolerably accurate field sketch may be plotted on paper; the former instrument will enable the sketcher to fix the positions of the different objects in plan, and by means of the latter and a small plummet line the contours of the ground may be found, and the different inclinations then shaded as per scale of shade.

The boxwood protractor has a scale of 33rds of an inch marked on the bevelled edge. Assuming 32 inches as the average pace of an individual, one mile will be equal to 1980 paces; so that, if required to make a military sketch on a scale of 6 inches to the mile, $\frac{1}{33}$rd of an inch would represent 10 paces—

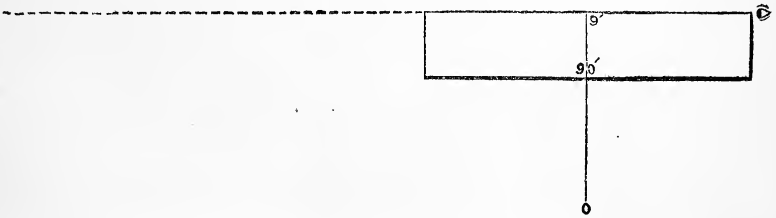
If on a scale of 12 inches to the mile, $\frac{1}{33}$rd = 5 paces.
" 24 " " " $2\frac{1}{2}$ "
" 30 " " " 2 "
" 60 " " " 1 "

In field sketching, the unit of measurement must be the pace; and this of course is a variable quantity, dependent upon the length of the individual's stride. If the sketcher's pace is wide of the 32 inches, a comparative scale may be shewn on his sketch afterwards; but it must be remembered that a military sketch does not pretend to very great accuracy, so that if his pace is within 2 inches of the assumed length of a pace, he may ignore the discrepancy.

The protractor can be used as a levelling instrument, and the contours of a hill sketched in, in the field.

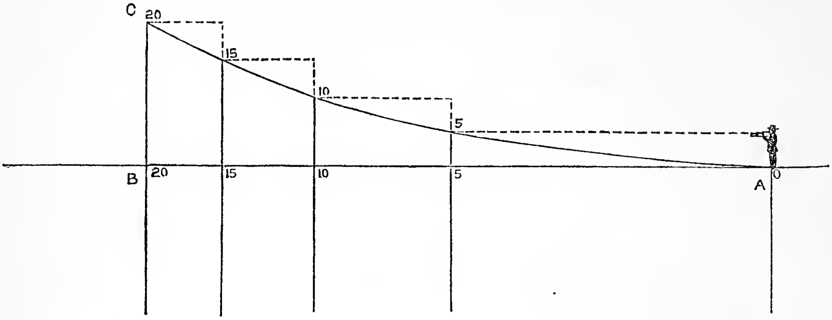
If a line about 6 inches in length, with a bullet attached to one end, and the other end of the line run through a hole in the protractor a little above the point numbered 9 on the scale of 33rds, and the protractor held in such a position that this plummet line coincides with the line joining the 9 and the 90°, by looking along the edge of the protractor we shall obtain a horizontal line. (Vide Fig. 4.) A series of contours can then be plotted with a vertical interval of the height of the sketcher's eye from the ground, the directions of the different watercourses having been laid down on paper. The sketcher can commence at the lowest point, and run a number of cross-sections over the ground. By joining the points of the same level, he will have obtained a plan of the contours. A cross-section can be run in the following manner:—Let *ABC* be the section of a hill. The sketcher, standing at a point *A*, and levelling up the incline, observes that point 5 is of the

Fig. 4.



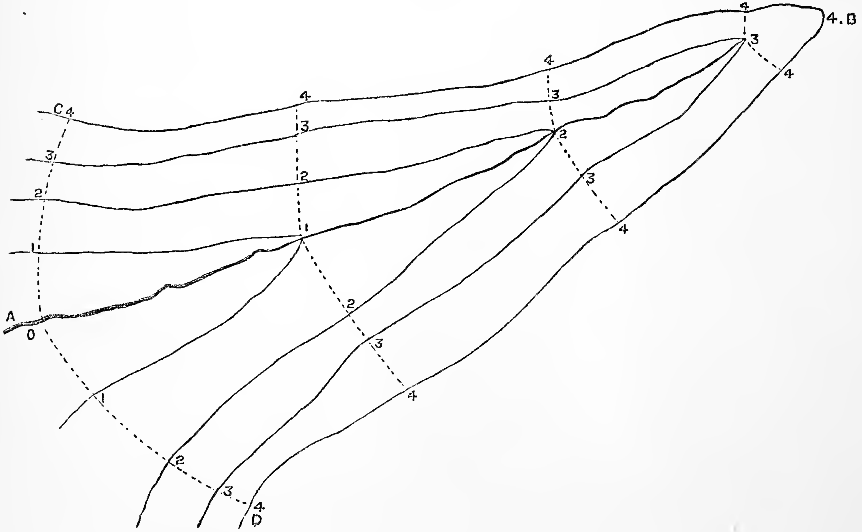
same height as his eye; he then paces to that point, plots on his sketch this distance according to scale, and numbers the point 5. He continues the same process from that point, until he arrives at the top of the hill, and will thus have represented that slope in plan by the contours marked 0, 5, 10, 15, 20. It will be noticed that the distance paced has been the hypothenuse of each right-angled triangle, whereas the base or distance apart in plan of the contours is required. When the inclines are gradual, the difference between the two distances will be comparatively small—by pacing a little *longer* than usual, the sketcher will have reduced the distance paced to its horizontal equivalent; but when the inclines are above 20°, instead of levelling, the best plan will be to observe the angle of inclination, and lay off the horizontal equivalents from the scale of shade, to get the distance apart of the contours in plan.

Fig. 5.



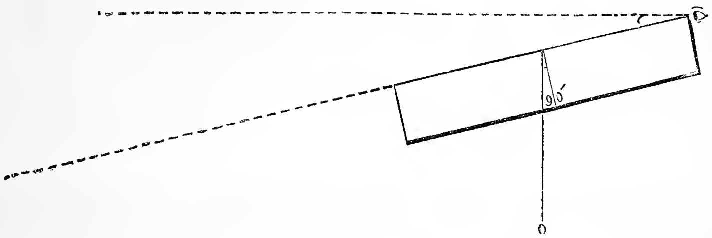
The best method of contouring by means of cross-sections is the following:—Let *AB* represent a watercourse; in order to obtain the contours of the slopes on either side of it, commence levelling from *A* to *B* up the watercourse; cross-sections can then be run from points 0, 1, 2, 3 in it, as

Fig. 6.



AC, AD, &c.; if then the points of the same level be joined—such as 1, 1, 1, 2, 2, 2—we shall have obtained the contours of the slopes. The sketcher must use his own judgment in sketching in the ground between the cross-sections. Of course, the greater the number of cross-sections, the more accurate the result should be.

Fig. 7.



The protractor and plummet can also be used as a clinometer, for measuring angles of elevation and depression. (Vide Fig. 7.) If a sketcher, standing on the top of a hill, directs the upper edge of his protractor to a point in the watercourse the same height as his eye, that angle of depression will be contained between the 90° on the protractor and the plummet line—which must be clamped carefully with the thumb of the left hand before moving the protractor, unless a friend is at hand to read the observed angle. By taking reciprocal angles of elevation and depression, a careful sketcher will find that his observations will be within half a degree of the truth. Having the angle of inclination, and the distance in plan between the top and bottom of the hill, from the scale of shade, the number and distance apart of the contours can be marked off. Supposing the slope to be 10° and the scale of drawing 6 inches to the mile, the shaded space marked 10° would give the horizontal equivalent for a 50 feet contour; if the scale of the drawing was 12 inches to the mile, the contours shewn would have a vertical interval of 25 feet. This, to my mind, is the best property of the scale of shade. The method of running cross-sections, while giving the most correct result, takes a long time in its operation; but when time is an object, and an approximation to truth only required, a few angles of inclination will be sufficient to guide the sketcher in filling in the contours of the different hills. This method will be most exact when the inclines are tolerably the same throughout; where the change of inclination is very marked, two angles of inclination may be observed instead of one, and the contours marked off accordingly. We shall then have sufficient data for depicting the ground by hachure shading.

The object of shading appears to be, to group the contours so that a general idea of the features of the ground may be conveyed to the mind at a glance; or, in other words, that the map may be deciphered as a *whole,* instead of as a number of isolated parts. The plan of grouping the contours by hachure shading, has certainly the advantage of enabling the sketcher to depict the minor ramifications of ground, as each stroke coincides with a contour at the spot it is drawn; but the time it takes in drawing (if anything like accuracy is attempted), is certainly an objection to this style of shading.

When a maximum amount of work is required in a minimum space of time —as is often the case with military topographers—the quickest method of grouping the contours is by shading with the brush (Indian ink, or Payn's grey are good neutral tints). The scale of shade will be of great service for sketching in the contours in the field; these contours can then be inked in, and the sketch shaded on the principle that the steeper the slope, the darker the shade ought to be to represent it. When shading with the *brush,* it is advisable to work up the drawing as a whole, instead of finishing one portion at a time. If the draughtsman is at all good with his brush, "working while the paper is wet," or "floating in colour," he will be able to produce an indistinct impression of the ground in a very short space of time; his picture can then be worked up, according to the time allowed and the purpose for which it is required.

In the accompanying sketch of Greenwich Park, the hachure shading alone took 1 hour 7 minutes; with the brush, the same ground was depicted in 18 minutes.

As only officers who have joined the service very lately have been taught the use of the scale of shade, I send this description of it for the information of the regiment. The notes on hill sketching have been added, as there are many officers quartered at out-stations who have plenty of spare time on their hands, and who, no doubt, would find both a pleasant and useful way of employing it would be by making a military sketch of two or three square miles of country around the fort or station they are quartered at.

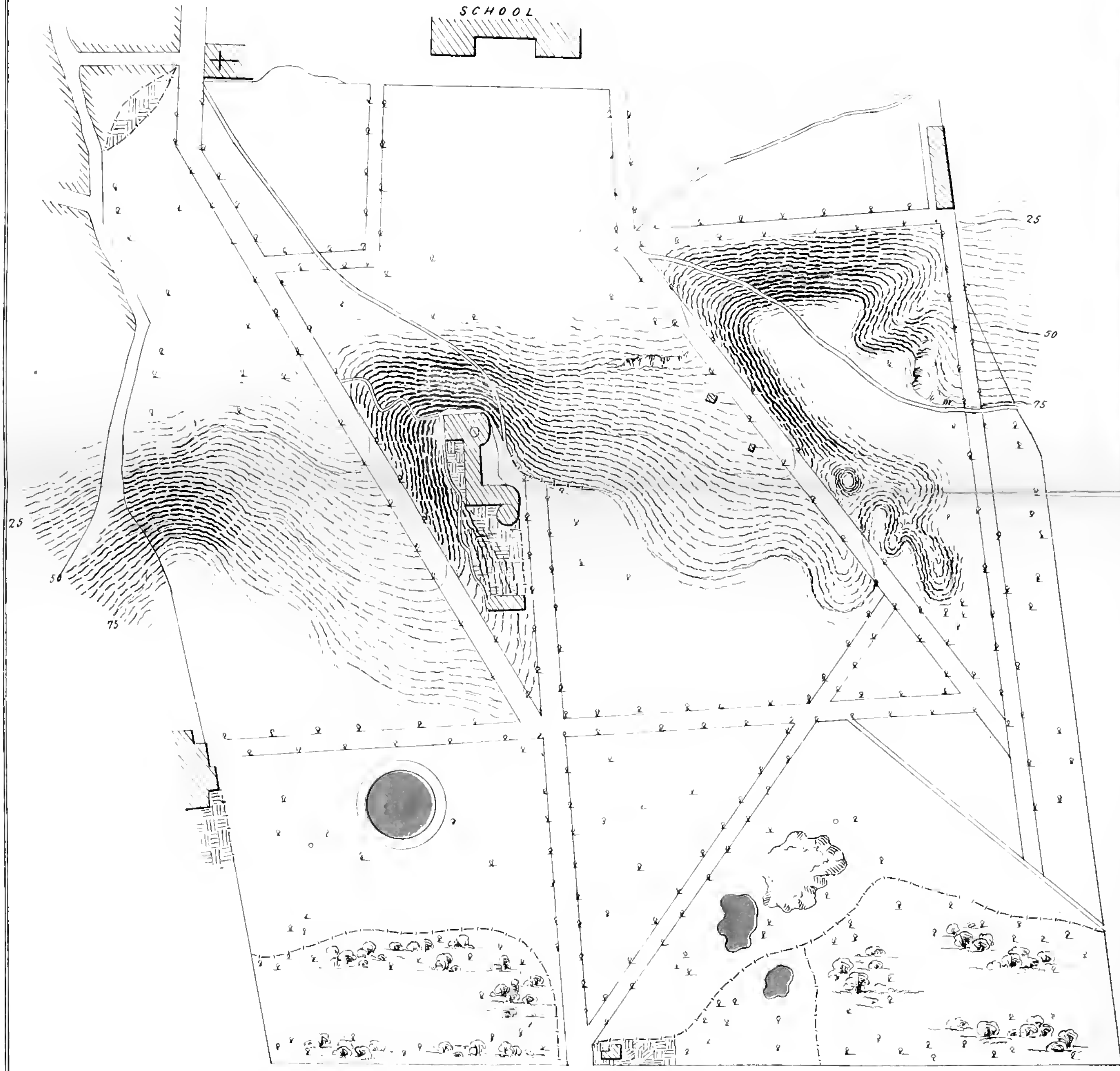
An outlay of about £2 10s. would provide instruments sufficient for the purpose, viz.—

A prismatic compass,
Scale of shade protractor, and
A sketching block (ruled for surveying).

SKETCH OF GREENWICH PARK.

Sketched in the field in 3 hours
Hill shading (in doors) 1^{hr} „ 7^{m}

Instruments used a P^{t} Compass
& Scale of shade protractor



G.A.C

Scale $\frac{1}{5280}$
72 inches to a Mile

Lithographed at the Royal Artillery Institution.

INDEX.

Additional List of War Office Photographs, in continuation of the one issued with Annual Report, 1868.

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*Nos.

2252—2252*a* Henry (4) Breech-loading rifle, submitted in accordance with W.O. Advertisement, October 22, 1866. Minute 20,221.
2253—2253*a* Wyley " "
2254—2254*a* Poultney " "
2255—2255*a* Laloux " "
2256—2256*a* Carter and Edwards (3) "
2257—2257*a* Soper " "
2258—2258*a* Glisenti (1) " "
2259—2259*a* Loron " "
2260—2260*a* Berdan " "
2261—2261*a* Koeing " "
2262 Jaspar " "
2263—2263*a* Greve and Dowling " "
2264—2264*a* T. Craig " "
2265—2265*a* Hammond " "
2266—2266*a* Lamson " "
2267—2267*a* Spencer " "
2268—2268*a* Henry " "
2269—2269*a* Hookham " "
2270—2270*a* Appleyard " "
2271—2271*a* Chassepôt " "
2272—2272*a* H. Craig " "
2273—2273*a* Witney " "

2276 Front view of Nos. 6 and 7, 7-inch wrought-iron plates, after two rounds from 68-pr. Charge 13 lbs. Range 10 yards. May 23, 1867.

2277 Back view of Nos. 2 and 3, 7-inch wrought-iron and steel plates, after practice with Major Palliser's chilled shot from 7-inch M.L. Woolwich guns, Nos. 28 and 33. Range 70 yards. Charges from 15 to 22 lbs. May 14, 1867.

2278 Back view of No. 8, 7-inch wrought-iron and steel plates after practice with Major Palliser's chilled shot from 7-inch M.L. Woolwich guns, Nos. 28 and 33. Range 70 yards. Charges from 15 to 22 lbs. May 14, 1867.

2279 Front view of No. 1, 7-inch plate of rolled and hammered iron combined, made by the Mersey Company, before being fired at.

2280 Front view of No. 29 target, after three rounds with shell, Nos. 1417 and 1418, from 9-inch M.L. gun. Charge 43 lbs. No. 1419, from 8-inch M.L. gun. Charge 30 lbs. Range 70 yards. June 5, 1867.

2281 Enlarged view of shot hole No. 1417, in No. 29 target.
2282 do 1418, do
2283 do 1419, do
2284 Showing point of shell (No. 1419) at back of 29 target.

2285 Enlarged view of shot hole (No. 1420) in No. 25 target, fired at from 8-inch M.L. gun. Charge 20 lbs. Range 70 yards. June 5, 1867.

2286 Back view of shot hole (No. 1420) in No. 25 target, fired at from 8-inch M.L. gun. Charge 20 lbs. Range 70 yards. June 5, 1867.

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* In giving an order it is enough to quote the NUMBER only.

2287 Front view of No. 1, 7-inch plate of rolled and hammered iron combined, after two rounds with chilled shot from 7-inch M.L. Woolwich guns, Nos. 33 and 6. Range 70 yards. Charges from 15 to 22 lbs.

2288 do after one additional round.

2289 Nos. 2 and 3, 7-inch wrought-iron and steel plates (reserved), after two rounds at each plate. June 12, 1867.

2290 Back view of No. 2, do

2291 Front view of Nos. 7 and 8, the former wrought-iron, and the latter wrought-iron and steel 7-inch plates, after one round at No 7, and four at No. 8. June 12, 1867.

2292 Back view of do

2293 Front view of No. 7, 7-inch wrought-iron plate, after one additional round. June 13, 1867.

2294 Krupp's 32-pr. smooth bore cast-iron gun.

2295 do

2296 Wedge of Krupp's 32-pr. smooth bore cast-iron gun.

2297 Front view of No. 1 plate of hammered and rolled iron combined, made by the Mersey Company, after one additional round with chilled shot from 7-inch M.L. Woolwich gun, No. 33. Charge 18 lbs. Range 70 yards. June 28, 1867.

2298 Back view of do do do

2299 Rodman 15-inch smooth bore cast-iron gun.

2300 Impression taken of bore of 10-inch cast-iron shell gun of 84 cwt., converted into 8-inch rifled gun of 93 cwt. on Major Palliser's system.

2302 Back view of inclined portion of No. 29 target, before being fired at from 15-inch Rodman S.B. gun.

2303 do

2304 Front view of inclined portion of No. 29 target, after three rounds from 15-inch Rodman S.B. gun, charge 60 lbs, range 70 yards; and two rounds from 9-inch M.L. rifled gun placed at a striking angle of 60°, charge 50 lbs., range 70 yards. July 24, 1867.

2305 Enlarged view of No. 1435 shot hole in No. 29 target.

2306 do 1436 do

2307 do 1437 do

2308 End view of inclined portion of No. 29 target, after three rounds from 15-inch Rodman S.B. gun, and two rounds from 9-inch M.L. rifled gun. July 24, 1867.

2309 15-inch shot after having been fired at inclined portion of No. 29 target.

2310 do

2311 Front view of direct portion of No 29 target, after one round (1440) with live chilled shell from 9-inch M.L. rifled gun, charge 43 lbs., range 70 yards. July 24, 1867.

2315 Wrought-iron trough with wooden tripod stand for firing all natures of Hale's rockets.

2316 Wooden trough for firing all natures of Hale's rockets.

2318 Front view of plates riveted together, after the practice with 7-inch M.L. gun. July 29, 1867.

2319 Back view, do

2323 10-inch M.L. gun, rifled on Woolwich system, rendered unserviceable by the breech being blown out at the 13th experimental round. Aug. 12, 1867.

2324 Breech of do

2325 No. 6, 5-inch test plate for fortifications, before being fired at.

2326 Front view of No. 6, 5-inch test plate, after three rounds from 68-pr. gun, charge 16 lbs., range 30 yards; and one round from 7-inch M.L. gun, charge 9 lbs., range 70 yards. August 14, 1867.

2327 Back view of do

2328 Mr Brierly's Experimental target, before being fired at.

2329 do after two rounds with chilled shot from 7-inch M.L. gun. August 20, 1867.

2330 68-pr. S.B gun No. 10893 on wooden garrison sliding carriage strengthened by the addition of an iron plate along the top of each cheek and fitted with side plate compressor. Burst August 22, 1867, charge 20 lbs.

2331 No. 7, 5-inch test plate, made by Brown and Company of Sheffield, before being fired at.

2332 Front view of No. 7, 5-inch test plate, after six rounds from 68-pr. gun, charge 16 lbs., range 30 yards; and one round from 7-inch M.L. rifled gun, charge 9 lbs., range 70 yards. August 30, 1867.

2333 Back view of do

2350 Grant's Cooking Apparatus, pontoon boilers, potatoe steamer, and coffee roaster.

2351 do Pontoon wagon.

2352 do Boiler wagon.

2353 do Frying pan and soup kettle.

2354 do Soup ladles, meat forks, meat guard and coffee tester.

2355 do Coffee Mill.

2356 Field service oven, Curragh pattern.

2357 do Aldershot pattern.

2358 Soyer's cooking apparatus.

2359 Fowke's fire-engine, limbered up.

2360 do ready for working.

2361 Hot shot furnace.

2362 15-inch Rodman cast-iron S.B. gun, elevated to 32° by means of skidding for the purpose of firing one round for extreme range and accuracy.

2363 No. 22 target, after one round from 8-inch, and two rounds from 64-pr. gun converted on Major Palliser's plan.

2364 No. 28 target after one round from Major Palliser's 8-inch converted gun.

2365 9-inch M.L. rifled gun, mounted on a wrought-iron garrison sliding carriage, and dwarf traversing platform.

2366 Mr Brierly's experimental target after two rounds from 9-inch M.L. rifled gun.

2367 No. 8, 5-inch test plate, before being fired at.

2368 Front view of No. 8, 5-inch test plate, after three rounds from 68-pr. S.B. gun, and two rounds from 7-inch M.L. rifled gun.

2369 Back view of do

2370 Mr Brierly's experimental target, showing the effect of two shot from 7-inch M.L. rifled gun, and one shot and one shell from 9-inch M.L. rifled gun.

2371 do second tier of rolled iron removed.

2372 Iron planks 13′ 2″ × 12″ × 5″, before being fired at, supported by wooden balks driven into the ground inside of supports 10 feet apart.

2373 Front view of iron planks 13′ 2″ × 12″ × 5″, after practice from 68-pr. S.B. gun.

2374 Back view of do

2375 7-pr. M.L. rifled steel gun mountain train for Abyssinia. Mule carrying gun.

2376 do

2377 do Mule carrying carriage.

2378 do do

2379 do Rocket Machine.

2380 do do

2381 7-pr M.L. rifled steel gun mountain train for Abyssinia. Ammunition boxes.
2382 do
2383 do Portable forge.
2384 do do
2385 do Miscellaneous stores.
2386 do do
2387 do Gun in action.
2388 do Method of rapidly transporting one or more guns in the field.
2389 do Tandem.
2390 do Rocket machine.
2391 do Pack-saddle, R. C. D. pattern.
2392 do do Otago pattern.
2393 do do fitted for carrying gun or carriage and wheels.
2394 do do do ordinary baggage.
2395 Front view of No. 9 test plate 8′ 2″ × 4′ 3½″ × 5″, before being fired at.
2396 Front view of No. 9 test plate, after three rounds from 68-pr. gun, and three rounds from 7-inch M.L. rifled gun. September 26, 1867.
2397 Back view of do
2398 Inclined portion of No. 29 target, after two rounds from 15-inch Rodman gun, and two rounds from 9-inch M.L. rifled gun. September 25, 1867.
2399 Back view of No. 1458 shot hole in No. 29 target made by 15-inch Rodman gun. September 25, 1867.
2400 Back view of No. 1459 do
2401 No. 29 target, after one additional round (No. 1462) from 9-inch M.L. rifled gun at a striking angle of 70°. September 27, 1867.
2402 Oblique view of inclined portion of No. 29 target after completion of practice. September 25 and 27, 1867.
2403 Three iron planks 10′ × 12″ × 5″ supported by wood balks driven into the ground, before being fired at.
2404 Front view of do after practice from 68-pr. S.B. gun. October 7, 1867.
2405 do after the pieces were collected.
2406 Back view of do
2407 No. 10 test plate 12′ 2″ × 4′ 6″ × 2,″ placed vertically between wood balks 10′ 8″ apart, before being fired at.
2408 Front view of No. 10 test plate, after five rounds from 68-pr. S.B. gun. October 16, 1867.
2409 Back view of do
2410 No. 11 test plate, 7′ 3″ × 4′ 1½″ × 5,″ after four rounds from 68-pr. S.B. gun, and one round from 7-inch M.L. rifled gun. October 16, 1867.
2411 Back view of do
2412 Front view Gibraltar Shield before being fired at.
2413 Side view of do
2414 Back view of Gibraltar shield, with rope mantelet down.
2415 do do do up
2416 Front view of Gibraltar shield after two rounds (Nos. 1469, 1470) from 9-inch M.L. rifled gun, October 25, 1867.
2417 Side view of do.
2418 do
2419 Back of right side of Gibraltar shield, showing the effect of No. 1469 shot.
2420 Back of left side of Gibraltar shield, showing the effect of No. 1470 shot.
2421 No. 22 (Armstrong and Whitworth) target, after six rounds from 7-inch M.L. rifled gun, October 23, 1867, to test the manufacture of Palliser's shot for the Royal Laboratory.

2422 Iron planks, 13′ 2″ × 5″ × 12″ (supported by wooden balks 10′ 5″ apart) after ten rounds from 68-pr. S.B. gun, October 31, 1867.

2423 do Rear view.

2424 Front of three iron planks [No. 163, 11′ × 16·5″ × 5,″ another 11′ × 16·5″ × 5″ (made of five thicknesses), and No. 7, 11′ × 16·5″ × 5″] placed between wooden balks 10′ 6″ apart, after eight rounds from 68-pr. S.B. gun, October 31, 1867.

2425 Back of do.

2426 Front of three iron planks (one 13′ 7″ × 12″ × 5″; No. 19, 16·5′ × 12″ × 5″; No. 44, 16′ 3″ × 12″ × 5″) made by Sir John Brown, Sheffield, after five rounds from 68-pr. S.B. gun, November 13, 1867.

2427 Back of do.

2428 Front of No. 12 test plate, 6′ × 4′ 5″ × 5″, swung by shackles, &c. after four rounds from 68-pr. S.B. gun, and one round with Palliser chilled shot from 7-inch M.L. rifled gun, November 5, 1867.

2429 Back of do.

2430 Front of No. 13 test plate, 5′ × 6′ × 5″, swung by shackles, &c. after four rounds from 68-pr. S.B. gun, and one round with Palliser chilled shot from 7-inch M.L. rifled gun, November 5, 1867.

2431 Back of do.

2432 An end piece of plate, 5′ 6″ × 2′ 6″ × 5″, swung by shackles, &c. after one round from 7-inch M.L. rifled gun, and one round from 68-pr. S.B. gun, November 5, 1867.

2433 Back of do.

2434 Front of iron planks after three additional rounds from 68-pr. S.B. gun, November 13, 1867.

2435 Back of do.

2436 Front of No. 14, test plate, 5′ 3″ × 5′ 3″ × 5″, swung by shackles, &c. after four rounds from 68-pr. S.B. gun, and one round from 7-inch M.L. rifled gun, November 13, 1867.

2437 Back of do.

2438 Inclined portion of No. 29 target after one round from 9-inch M.L. rifled gun, at a striking angle of 80°, November 1, 1867.

2439 E.O.C. 8-inch rifled M.L. shunt gun destroyed at 2nd round of experiment, November 20, 1867.

2440 9-inch M.L. rifled gun No. 215 F. R.G.F., Experimental No. 331. Impressions of bottom of bore after various rounds.

2441 Impression taken of 9-inch M.L. rifled gun No. 215 R.G.F. Experimental No. 331. After 100 rounds.

2442 do After 200 rounds.

2443 do After 300 rounds.

2444 do After 400 rounds.

2445 do do do.

2446 do After 500 rounds.

2447 do do do.

2448 do do do.

2449 Gun-cotton experiment. 8-inch shell burst in gun.

2450 Portion of No. 29 target. Trial shot from 9-inch M.L. rifled gun to obtain elevation for experiment to test bolts, November 28, 1867.

2451 Front of iron planks supported by wooden balks, after ten rounds from 68-pr. S.B. gun, November 28, 1867.

2452 Back of do.

2453 Two 5-inch plates bolted together by 14 screw bolts; front plate 6′ 9″ × 5′, and back do, 9′ × 5′. Before being fired at.

2454 do after two rounds from 9-inch M.L. rifled gun, Nov. 28, 1867.

2455 Two-5-inch plates bolted together by 14 screw bolts; front plate 6′ 9″ × 5′, and back do, 9′ × 5″. After an additional round, November 28, 1867.

2456 Back of do.

2457 Front of back plate after the bolts were removed.

2458 Back of front do do

2459 Bolts removed from the plates after practice.

2460 Experiment proposed by Major Palliser to test blocks of chilled cast-iron *versus* blocks of common grey cast-iron as a backing for armour plates. A block 3′ × 2′ × 1′ 8″ resting on wooden balks and butted against Samuda's target, after one round from 68-pr. S.B. gun, December 3, 1867.

2461 do do A round block, diameter 3′ 6″ × 1′ 10″ after one round from 68-pr. S.B. gun, and one round from 7-in. M.L. rifled gun, December 3, 1867.

2462 do do A block 3′ × 2′ × 1′ 6″ after one round from 68-pr. S.B. gun, December 3, 1867.

2472 Gun-cotton experiment. 7-inch steel shell burst in gun.

2473 Front of iron planks, after eight rounds from 68-pr. S.B. gun, 6th Dec. 1867.

2474 Back of do.

2475 Front of No. 15 test plate, about 4′ 6″ × 4′ after one round from 68-pr. S.B. gun, and one round from 7-inch M.L. rifled gun.

2476 Back of do.

2477 Front of iron planks after nine rounds from 68-pr. S.B. gun, Dec. 20, 1867.

2478 Back of do

2479 Front of iron planks after five rounds from 68-pr. S.B. gun, Dec. 20, 1867.

2480 Back of do.

2481 Front of iron planks after five rounds from 68-pr. S.B. gun, Dec. 31, 1867.

2482 Back of do

2483 Front of iron planks after seven rounds from 68-pr. S.B. gun.

2484 Back of do

2485 Front of iron planks after eight rounds from 68-pr. S.B. gun, Dec. 31, 1867.

2486 Back of do

2495 Front of iron planks after five rounds from 68-pr. S.B. gun, Jan. 16, 1868.

2496 Back of do

2497 Front of iron planks after twelve rounds from 68-pr. S.B. gun, Jan. 21, 1868.

2498 Back of do

2499 12-pr. M.L. gun mounted on a 9-pr. steel carriage.

2500 9-pr. steel carriage, after firing 306 rounds from 12-pr. M.L. gun, and 108 rounds from 3-inch bronze gun.

2515 Back of front 5-inch plate placed against 8-inch target, after four rounds, March 17, 1868.

2516 Back of back, do

2517 Back of both 5-inch plates placed against 8-inch target, after four rounds, March 17, 1868.

2518 Vent pieces of Armstrong breech-loading guns, cut in section to shew the effect of repeated discharges in enlarging the channel.

2519 do do

2520 General view. Cannon of Muhammad II. Cast A.H. 868 (A.D. 1464).

2521 View taken from behind do

2522 View of the muzzle, do

2523 Enlarged view, do

2524 Impression taken of 9-inch M.L. rifled compound gun, before the commencement of the experiment.

2525 do after 139 rounds, in addition to 20 rounds battering charges in smooth-bore state.

2526 Impression taken of 9-inch M.L. rifled compound gun, after firing 239 rounds in addition to 20 rounds battering charges in smooth-bore state.
2527 do after firing 339 rounds, in addition to do
2528 do do 439 do
2529 Impressions taken right, left, and up, of 9-inch M.L. rifled compound gun, after firing 489 rounds in addition to 20 rounds battering charges in smooth-bore state.
2530 Impression taken up do.
2531 Impression taken from muzzle to left of up do.
2532 Impression taken left and up, after firing 500 rounds, 64-pr. M.L. rifled gun.
2533 Impressions taken left and up of 64-pr. M.L. rifled gun after firing 1000 rounds.
2534 Impressions taken left and up, after firing 1500 rounds.
2535 do do 2000 rounds.
2536 Target representing the Plymouth breakwater fort, in course of construction.
Placing uprights in position.
2537 do Uprights fixed.
2538 do First layer of horizontal plate and planks in position.
2539 do Second layer of perpendicular plate and planks in position.
2540 do Third layer of horizontal plates in position.
2541 do Shewing construction of iron roof.
2542 do The brickwork filling of roof.
2543 do Method of securing the uprights to roof, and the plan adopted for filling in the concrete.
2544 do Method of securing the curved 5-inch plates.
2545 do End view, shewing the three layers of plates and planks.
2546 Millwall shield, shewing the hollow stringers and the filling in with wood and T irons.
2547 Millwall shield, bottom 9-inch armour plate in position.
2548 Front of Millwall shield, completed.
2549 Back of do.
2550 Steel plate brackets after two rounds 9-pr. common shell, May 13, 1868.
2551 Gun-metal nave, after one round 9-pr. common shell, May 13, 1868.
2552 Cast-iron nave, after one round 9-pr. common shell, May 13, 1868.
2553 Wrought-iron brackets after four rounds 9-pr. common shell, May 13, 1868.
2554 do do
2555 Wood nave after one round 9-pr. common shell, May 13, 1868.
2561 Front of Millwall iron planks, continuation of proof, March 30, 1868, 68-pr. S.B. gun.
2562 Back of do.
2563 Front of Millwall iron planks, continuation of proof, March 31, 1868, 68-pr. S.B. gun.
2564 Back of do.
2565 Front of do.
2566 Back of do.
2567 Front of Millwall iron planks, continuation of proof, April 6, 1868, 68-pr. S.B. gun.
2568 Back of do.
2569 Front of do.
2570 Back of do.
2571 Front of Millwall iron planks, continuation of proof, April 20, 1868, 68-pr. S.B. gun.
2572 Back of do.
2573 Front of do.
2574 Back of do.

2575 Front of Millwall iron planks, continuation of proof, May 11, 1868, 68-pr. S.B. gun.
2576 Back of do.
2577 Moncrieff's 7-ton gun-carriage. Firing position.
2578 do do Nearly down to loading position.
2579 do do Rear elevation, showing carriage nearly down to loading position.
2580 Plan of Plymouth harbour reduced from the Admiralty Chart.
2581 Palliser 9-inch M.L. rifled gun, No. 1745, made by Sir W. G. Armstrong and Co., experimental No. 359, burst at Woolwich May 30, 1868, at the second round.
2582 do do
2608 Front of 8-inch rolled iron plate (Cammell & Co.) tested in the ordinary manner at Portsmouth with 68-pr. shot, afterwards used to compare chilled projectiles made of ballast iron known as "Seeley's pig."
2609 Back of do.
2610 Sections of fuzes supplied to field artillery.
2611 Front of 10-inch armour plate, manufactured by Sir J. Brown & Co., after three rounds from 9-inch M.L. rifled gun, June 5, 1868.
2612 Back of left side of do.
2613 Back of right side of do.
2614 10-inch armour plate, thrown on its face to show effect of round 1500.
2615 Target representing the Plymouth breakwater fort. Placing extra 5-inch plate in position on western side.
2616 General view of experimental structures.
2617 Target representing Plymouth breakwater fort, June 16, 1868.
2618 Interior of casemate, showing the port struts, Nos. 3 and 4.
2619 do do.
2620 General view of interior of casemate, with mantelet lying down.
2621 do do showing the old brickwork arch.
2622 Interior of casemate, showing recess between target and pier on left of port.
2623 Battery erected at 200 yards from the experimental structures, viz. 15-inch Rodman 9, 12, 10, and 7-inch M.L. guns.
2624 Front of target representing Plymouth breakwater fort after the following rounds, viz. 12-inch Palliser shot, 12-inch Palliser shell, and two rounds of 15-inch Rodman shot, at 200 yards range, June 16, 1868.
2625 Interior of do.
2626 Front of casemate, after three rounds of 12-inch Palliser shot, and one round of 12-inch Palliser shell, range 200 yards, June 16, 1868.
2627 Interior of do.
2628 Front of casemate, after one round of 15-inch Rodman shot, one round of 12-inch Palliser shot, one round of 12-inch Palliser shell, and two rounds of 10-inch Palliser shell, range 200 yards, June 17, 1868.
2629 Interior of do.
2630 Front of casemate after one round of 10-inch Palliser shell and one round of 12-inch Palliser shell, range 200 yards, June 17, 1868.
2631 Interior of do.
2632 Right top corner of casemate, shewing effect of round 1520.
2633 Interior of casemate, shewing right side of port after practice, June 17, 1868.
2634 do do left side of do
2635 Front of casemate after two rounds of 12-inch Palliser shell, one round of 15-inch Rodman shot, and one round of 10-inch Palliser shell, range 200 yards, June 18, 1868.
2636 Front of casemate after two rounds of 10-inch Palliser shell, range 200 yards, June 18, 1868.

2637 Right top corner of casemate after round 1523.
2638 Interior of casemate, after round 1524.
2639 Front of casemate after round No. 1527, 15-inch Rodman shot, range 200 yards, June 18, 1868.
2640 15-inch rolled iron plate made by Messrs Brown and Co.
2641 do after one round of 12-inch Palliser shot, range 200 yards, June 16, 1868.
2642 do after one round of 10-inch Palliser shot, and one round of 10-inch Palliser shell, range 200 yards, June 17, 1868.
2643 do after one round of 12-inch Palliser shell, and one round of 15-inch Rodman shot, range 200 yards, June 18, 1868.
2644 15-inch hammered iron plate, made by the Thames Iron Works Company.
2645 do after one round of 12-inch Palliser shot, range 200 yards, June 16, 1868.
2646 do June 17, 1868.
2647 Enlarged view of a fragment of do
2648 Front of do, after pieces were collected and built up.
2649 Back of do
2650 Interior of target representing Plymouth Breakwater Fort, shewing method of securing rope mantelet, after termination of practice, June 18, 1868.
2651 Top of right side of do, after termination of practice, June 18, 1868.
2652 Interior of do
2653 Interior of left side of do
2654 Front view of experimental casemate, before being fired.
2655 do with 7-inch gun in position.
2656 Back of experimental casemate, shewing the old brickwork arch.
2657 do
2658 Enlarged view of back of experimental casemate.
2659 Front of experimental casemate after practice with Palliser chilled shot, June 23, 1868.
2660 Back of do
2661 Front of do
2662 Back of do
2663 Enlarged back view of No. 1545 shot hole in experimental casemate.
2664 do 1546 do
2665 Interior of casemate after round 1550, June 24, 1868.
2666 Front of experimental casemate after rounds 1551 to 1558, June 24, 1868.
2667 Back of do
2668 Front of do, after termination of practice, June 24, 1868.
2669 Back of do
2670 Front of 15-inch rolled iron plate after pieces were collected, &c.
2671 Back of do
2672 No. 1861, 7-inch Palliser gun, burst July 1, 1868, when firing a recovered Palliser shot.
2673 do
2674 Front of target representing Plymouth Breakwater Fort and experimental casemate, before being fired at from mortars, five feet of earth having been placed on the roof.
2675 Back of do
2676 Front of do, after rounds No 1562 to 1564.
2677 Back of do
2678 Front of do, after a salvo, rounds Nos. 1575 to 1577.
2679 Back of do
2680 Enlarged view of portion of do, shewing effect of the salvo.
2681 Rope mantelet used with target, after practice, July 8, 1868.

2682 Front of experimental casemate after rounds Nos. 1565 to 1568.
2683 Back of do
2684 Front of do after rounds Nos. 1569 to 1574.
2685 Brierly target, before being fired at.
2686 Front of do, after rounds Nos. 1578 to 1580.
2687 Right side of do do
2688 Left side of do do
2689 Right side of Millwall shield, before being fired at.
2690 Left side of do.
2691 Front of do, after rounds Nos. 1581 to 1587, and 1589 to 1591.
2692 Right side of do do
2693 Front of do. after rounds Nos. 1592 to 1595.
2694 Right side of do. at conclusion of practice, July 16, 1868.
2695 Left side of do do
2696 Back of do do

R.A. Institution, Woolwich,
30th June, 1869.